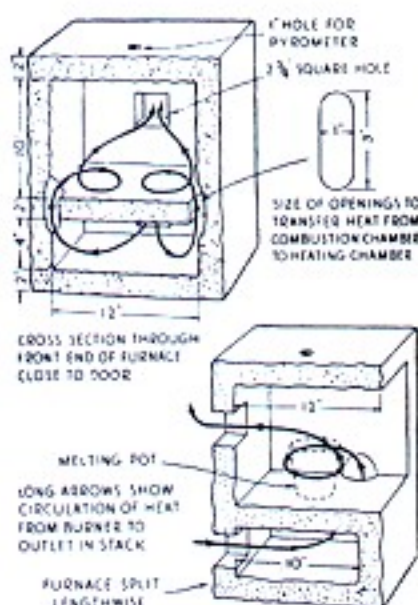


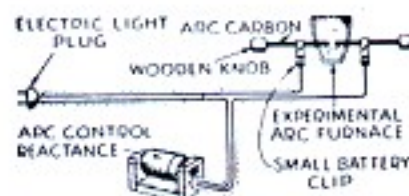
THE SURVIVOR

Volume 3

By Kurt Saxon



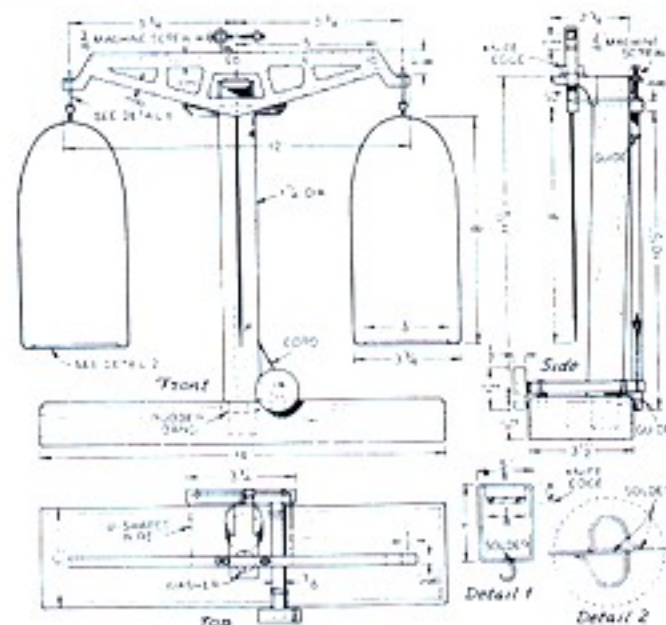
Two cutaway diagrams of the furnace showing method of arranging the slabs of fire brick



How the connections are made. No current can flow without passing through the coil



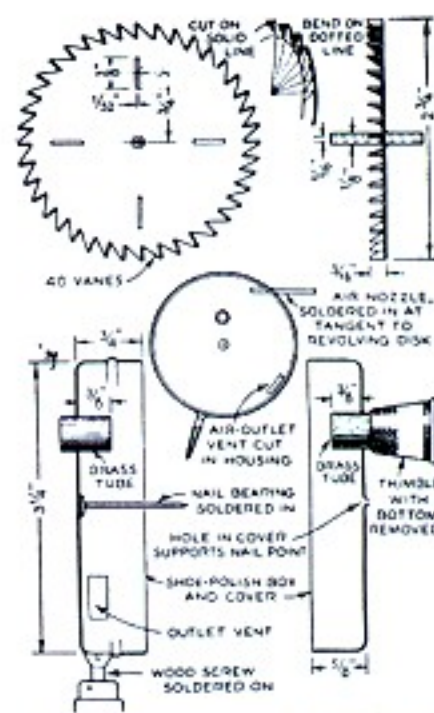
With this arrangement a loaf of bread can be baked clear through over the camp fire



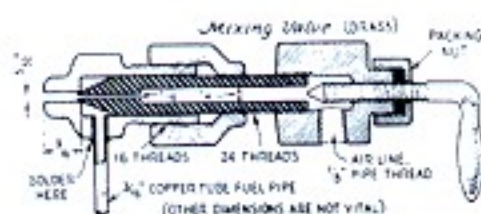
Top, front, and end views of the complete beam balance, and two detail drawings, the first showing the knife-edge hangers and the second, the pan supports bent from wire

JUST A FEW OF THE ARTICLES IN VOLUME 3

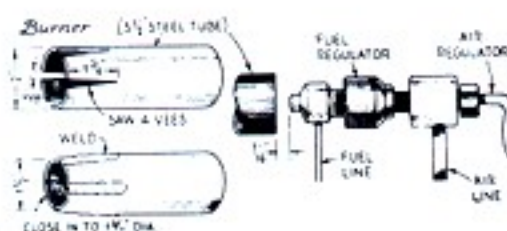
- AMATEUR ELECTRICIAN'S HANDBOOK, 1924 (366 pages)
- THERMOS BOTTLE COOKING
- IMPROVISED WEAPONRY
- GARDENING
- SURVIVAL FOODS
- TOOLS AND WORKSHOPS
- HOME CHEMISTRY
- MAKING MOCCASINS
- LIE DETECTOR —HOMEMADE
- FOOD DEHYDRATING COMPLETE COURSE
- STROBOSCOPE —HOMEMADE
- HOME BUSINESSES
- BASIC ELECTRONICS
- ELECTROPLATING
- STEAM DRIVEN AIRPLANE
- LABORATORY EQUIPMENT
- WIND DRIVEN BATTERY CHARGER
- SOLAR POWER OF THE PAST
- KNIVES, THROWING
- TOY MAKING



A shoe-polish box, a rubber bulb, and a few other odds and ends are all you need to make this interesting device. The details of construction are shown in the photo and drawing



Cross-section view of the mixing valve, sketch of burner tube, and diagram showing space to maintain between them



A BOY'S PERISCOPE FOR LOOKING OVER WALLS

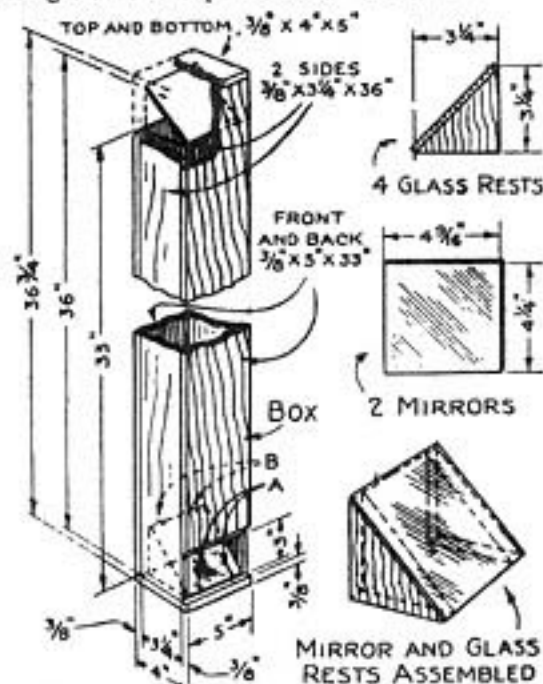


With a periscope
you can see with-
out being seen

WHEN playing "war," "submarine," and "cops and robbers," no toy is of quite so much use to a boy as a small periscope with which to look over fences and around corners. Such a periscope is very easy to construct if two small mirrors can be obtained. It may be made of pine or other light wood, and the dimensions may be changed to suit the fancy of the maker. The only real accuracy necessary is in placing the mirrors; they must be exactly parallel.

If made the size shown, the back and front of the box are $\frac{3}{8}$ by 5 by 33 in., the two sides $\frac{3}{8}$ by $3\frac{1}{4}$ by 36 in., and the top and bottom each $\frac{3}{8}$ by 4 by 5 in. The four glass rests are made to an accurate angle of 45° . Paint the inside surfaces white and assemble all pieces of the tube as shown, using glue and $\frac{1}{4}$ -in. No. 17 brads. Fit the glass rests and fasten them with $\frac{5}{8}$ -in. brads. After checking the dimensions, cut two mirrors as shown and hold them in place with $\frac{1}{2}$ -in. wire nails as indicated at A and B.

In using the periscope, push the tube above a wall or beyond a corner and look into the bottom mirror from the rear. You will be able to see everything within range of the top mirror.—C. K. A.



The only real accuracy necessary in the construction is in the placing of the mirrors

THE CHALLENGE AND REWARDS OF SURVIVAL

By Kurt Saxon

"Bang. Bang. Bang. Bang. Four shots ripped into my groin and I was off on the greatest adventure of my life." This is the first line in Max Shulman's hilarious book, "Sleep Till Noon." The line had nothing to do with Max's novel but he thought it a good way to begin a book.

The idea, however, does apply to the Survivalist. If you are alive ten years from now you will have gone through some wild scenes you can't imagine now. The worst calamities you overcome will give you the greatest gratification of any other life experience.

There are so many factors in surviving the collapse of a great civilization that anticipating the worst will stimulate the heroism in every Survivalist. Regardless of the horror of facing such chaos, your efforts will take you to a plateau which will justify any hardship.

As a Survivalist, that is, one who anticipates and prepares for the worst man and Nature can hand out, you will be automatically among the elite. Whether you are now a doctor or a dishwasher, you will be in your grandchildren's history books.

You will have done what only the best of any race has done down through the ages. You will be preserving and passing on the life-sustaining knowledge of our culture and its past glories. In surviving yourself, you will be the means of survival for those born later.

Civilizations and systems have been growing, thriving and then dying since before written history. A modern person reading history can accept the collapse of any number of past societies without any fear of the same fate. After all, those who died didn't have his god, his government or his science. Of course, most individuals of past doomed civilizations felt the same about their own unfortunate and unenlightened ancestors and less powerful neighbors.

You might imagine the Roman welfare recipient in the stands of the Coliseum. There he was, gloating and enjoying the agony of the inferior pagans being slaughtered in the arena.

He was invincible. He was a Roman. The victims in the arena were only Barbarians. They were losers and died because they didn't merit Roman citizenship.

But Roman citizenship, its Legions, its overrated efficiency doomed that same proletarian gloating in the stands to starvation or enslavement by his "inferiors" just a short time later.

I consider it arrogance, verging on paranoia, for a person to believe that he can escape the natural consequences of his own, and his fellows degeneration. Of course, degeneration of social systems and even individuals is usually so gradual that it goes unnoticed by its victims.

For instance, if you see a person often for ten years, you notice little real change. But at a reunion you see those old friends and relatives as falling apart. They see you as being over the hill, too. The same applies to a modern city you haven't seen in ten years. It is dirtier, more smoggy, the people shabbier and more funny looking. Degeneration, so apparent to the long absent observer, is hardly noticed by the subjects who are so much less than they had been.

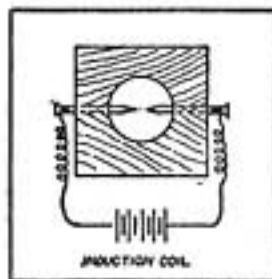
Aside from people simply growing older or cities getting shabbier and more run down, with more losers filtering in through failure to cope, stable, industrious people also degenerate. A workman, once proud of his skill, no longer looks for better opportunities when his workmanship isn't appreciated. Instead, he works less, depending on his union to answer for his increasing sloth.

He is less able than he was and he gradually becomes so dependent on others to arbitrate for him that his own efforts on the job become increasingly less important. When his company goes bankrupt due to his union's emphasis

Popular Mechanics 1914

To Explode Powder with Electricity

A 1-in. hole was bored in the center of a 2-in. square block. Two finishing-



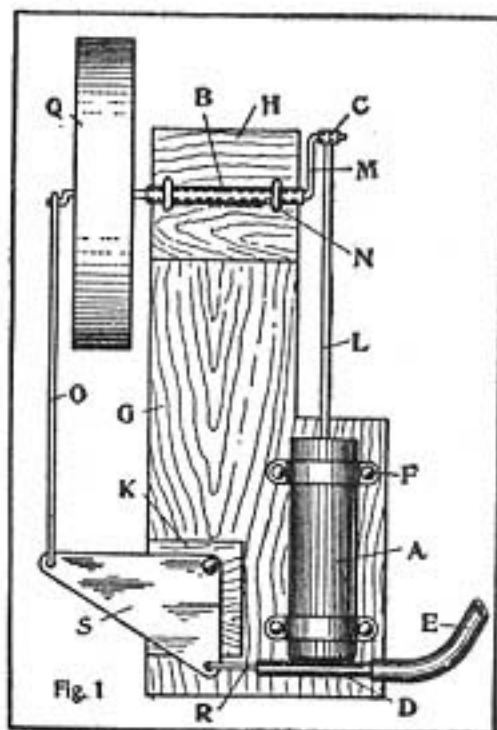
nails were driven in, as shown in the sketch. These were connected to terminals of an induction coil. After everything was ready the powder was poured in the hole and a

board weighted with rocks placed over the block. When the button is pressed or the circuit closed in some other way the discharge occurs. The distance between the nail points—which must be bright and clean—should be just enough to give a good, fat spark.—

Popular Mechanics 1913

How to Make a Toy Steam Engine

A toy engine can be easily made from old implements which can be found in nearly every house.



Toy Steam Engine Assembled

The cylinder A, Fig. 1, is an old bicycle pump, cut in half. The steam chest D, is part of the piston tube of the same pump, the other parts being used for the bearing B, and the crank bearing C. The flywheel Q can be any small-sized iron wheel; either an old sewing-machine wheel, pulley wheel, or anything available. We used a wheel from an old high chair for our engine. If the bore in the wheel is too large for the shaft, it may be bushed with a piece of hard wood. The shaft is made of heavy steel wire, the size

on pay raises and benefits over production, he goes on welfare. He has gone from a skilled worker to a parasite with no feelings of inadequacy.

The gradualism by which he reached this sorry state has blinded him to his downward progress. Psychologically, he can be quite stable and even intelligent. In fact, the stable and the intelligent are in many ways less well equipped than the "neurotic doom-shouters" most such people consider Survivalists to be.

A few years ago, a Boeing plant lost a big government contract. Hundreds of well-to-do, highly skilled workers in engineering and even management were laid off. They had sumptuous homes, several cars each and had previously been insulated against socio-economic difficulties through their positions. They were so secure many of them didn't even feel the need for bank accounts. Everything they earned went to pay for their lifestyles of frivolity and conspicuous consumption.

They were the most shocked of all to go on welfare and even accept food baskets from private donations. These were the intelligent ones. These were the stable and productive, guaranteed security by the society they served.

I said they were stable and intelligent. Yet, they were more vulnerable than most welfare recipients, for they considered themselves an important part of the Establishment it could not do without. But when their little world temporarily crashed they didn't have the survival potential of a scrounging wino.

Consider also, the over-forty executives laid off from thousands of firms either bankrupt or seeking younger men with fresh ideas. Oh, how they seek work befitting their skills! And how they lament the present lack of recognition they so long considered their due.

So intelligence and competence on behalf of a crumbling Establishment is a curse rather than a blessing. All it did was to insulate them from reality.

The Establishment's presently favored are no more, and often less, able to cope with adversity than losers used to the demeaning aspects of Welfareism. In point of fact, the educated specialists, the elite of the Establishment, are doomed more surely than are their own domestic servants.

Another factor overlooked by non-Survivalists is that the more complex a civilization becomes, the less able its members are to apply their intelligence and training to survival situations. Also, the person who specializes in a narrow field loses his ability to see the whole picture, on the job and off.

An example might be a brilliant researcher in a ceramics factory working on some narrow specialty. In another department a relatively mindless drudge watches for cracks in an unending train of ceramic pieces passing before him on the inspection line. Each feels secure. Yet, each is equally a minor part of their profession, equally restricted in their application of their skill or labor to the factory.

Consider a village potter of two hundred years ago. He had a kick-wheel, made his own plaster molds, dug his clay from the river bank and did every process, from purifying the clay to firing the week's output.

The two above; the researcher and the cup and saucer inspector are too narrow in their specialties to start over on their own. However, the village potter, having nothing but the basics but a full understanding of the process from start to finish can begin again. The narrow specialist and the inspection worker would be out of the field.

This analogy fits the average American today. He knows only bits and pieces of a rather large field of the industry which supports him. The breakup of that industry will turn the specialized genius into a functional moron. That is, his expertise will be useless and so he will be no more able to carry on the industry than the dimwit on the line.

So when an Establishment falls, its dependents, whether intellectuals, laborers or welfare recipients are pretty surely doomed. Dependency applies just the same to the corporation brain as to the welfare recipient.

Survivalists throughout the ages have been largely independent of their respective Establishments. The small farmer, the blacksmith, the carpenter,

and a central pipe with its upper opening above the top of the outer dome.

At night, cold air pours down the central pipe and circulates through the core as shown in the diagram. By morning the whole inner mass is so thoroughly chilled that it will maintain its reduced temperature for a good part of the day. The well is now ready to function.

Warm, moist outdoor air enters the central chamber, as the daytime temperature rises, through the upper ducts in the outer wall. It immediately strikes the chilled core, which is studded with rows of slates to increase the cooling surface. The air, chilled by the contact, gives up its moisture upon the slates. As it cools, it gets heavier and descends, finally leav-

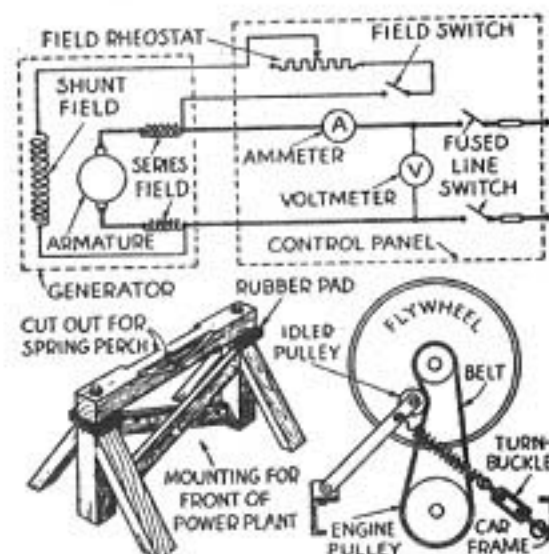
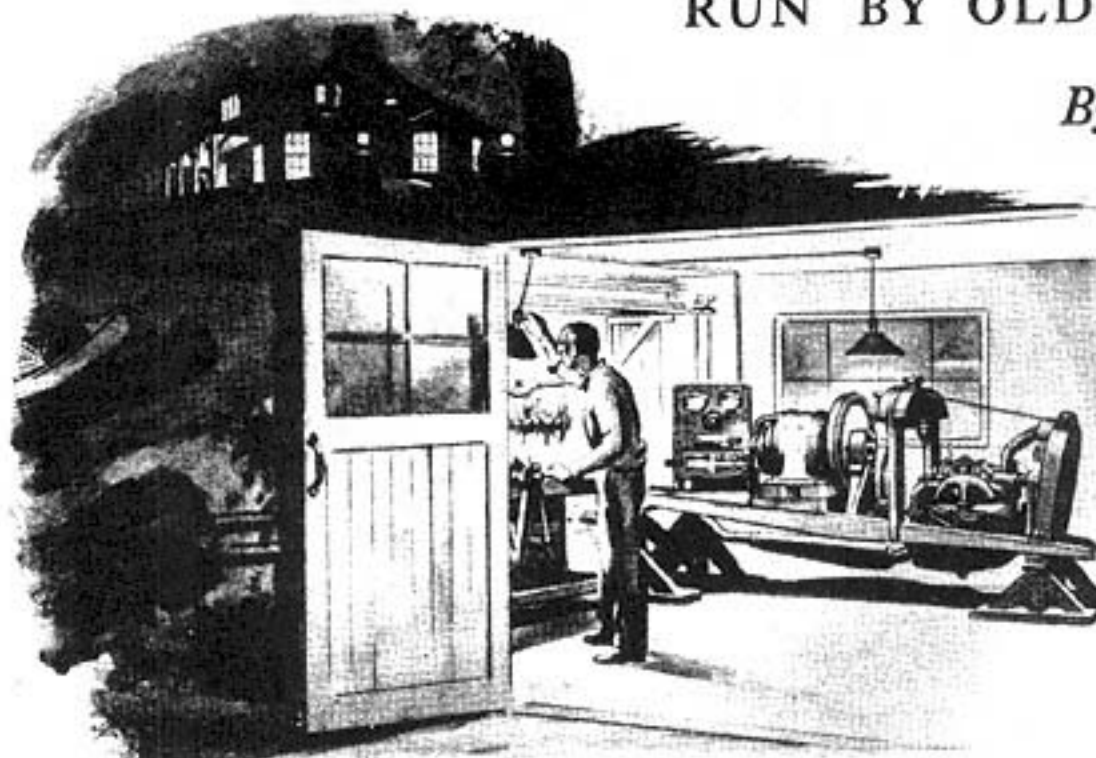
ing the chamber by way of the lower ducts. Meanwhile the moisture trickles from the slates and falls into a collecting basin at the bottom of the well. By this principle, the inventor believes it possible to obtain as much as 6,000 gallons of water daily for every 1,000 square feet of condensing surface.

Small Electric Power Plant

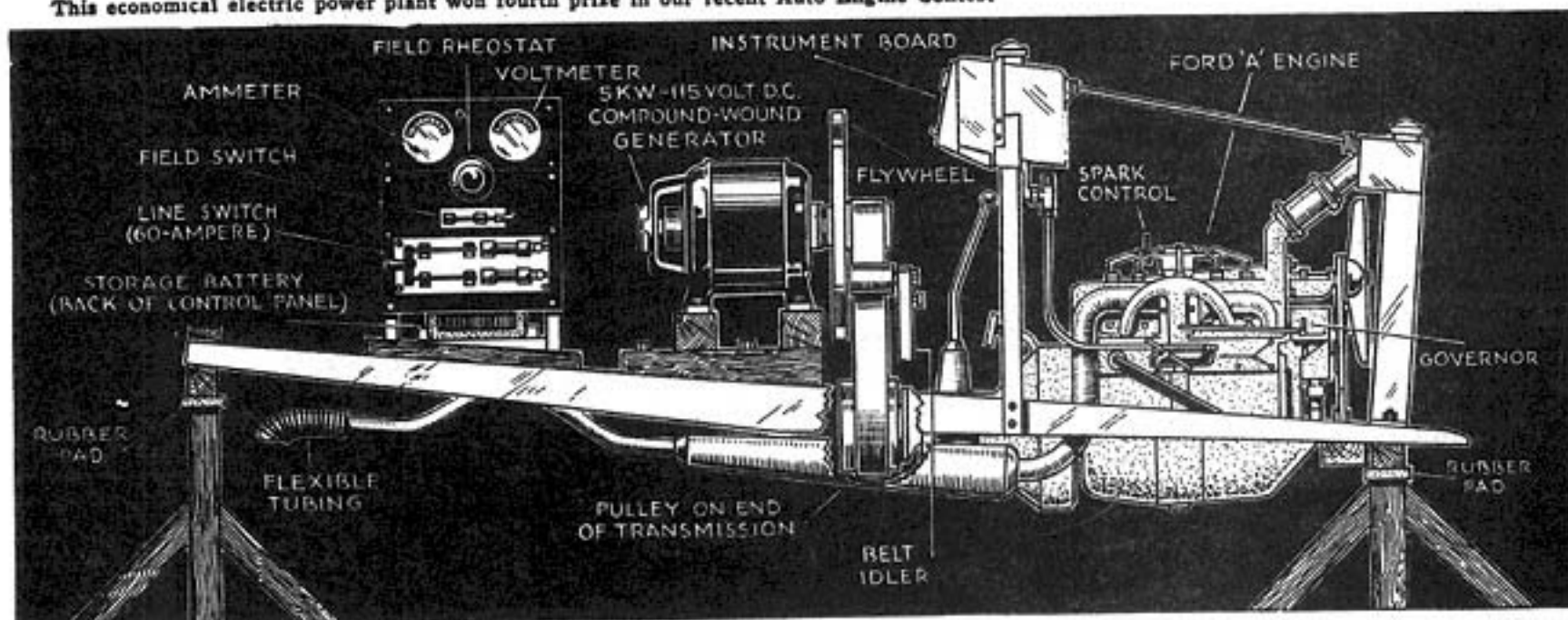
RUN BY OLD AUTO ENGINE

By J. L. Bird

Popular Science
JULY, 1933



This economical electric power plant won fourth prize in our recent Auto Engine Contest



The general arrangement of engine, generator, and switchboard, and (above) the wiring diagram, belt-tightening device, and one of the horses

MANY districts in our country are still without electric power facilities. It is quite easy and inexpensive to construct a dependable power plant by using an automobile engine for the motive power.

The chassis of a discarded or wrecked car, stripped of all equipment except the engine and radiator, serves as the mounting for the generating equipment. The drawing below shows a Ford "A" engine, but any other type will serve equally well.

Support the car frame on two wooden horses made as shown. To reduce vibration, build in rubber pads constructed of several layers of inner-tube rubber. The rear support should be higher than the front so that the generator shaft will be

perfectly level. This will eliminate excessive armature end play.

Purchase from a dealer in used electrical equipment a good 5-K.W., 115-volt D.-C. compound-wound generator. A shunt machine will also serve, but the compound winding will give better voltage regulation on heavy loads. The cost of such a generator at second-hand value will be approximately \$50.

The builder should also purchase an engine speed governor, such as that used on Fordson tractors, costing about \$14.

On the rear of the engine-transmission housing, mount a drive pulley at least 10 in. in diameter.

Support the generator on hardwood

cross members as indicated. It is recommended that the generator be fitted with a flywheel, which will tend to maintain a more uniform generator speed when heavy electrical loads are suddenly applied or removed. An old automobile flywheel or the type used on cordwood saws will serve admirably for this purpose.

The generator's rated speed will probably be 1,800 R. P. M. The most economical engine speed is in the neighborhood of from 900 to 1,000 R. P. M. The generator belt pulley should, therefore, be approximately one half the diameter of the drive pulley. A belt-tightening device to maintain positive belt tension is easily constructed, as shown.

The regular car gas tank should be mounted on supports to use gravity feed for the gasoline. The instrument panel may be left intact in its original position.

Engine controls may be left nearly unchanged. The gear shift lever should be bent forward to clear the generator. Spark control may be had by mounting a small lever on the engine head. The governor will operate the throttle. Electric starting may still be used and may even be arranged for remote control.

A control panel containing an ammeter, a voltmeter, field rheostat, field switch, and line switch is shown on the sketch. The meters are not absolutely essential, but serve to check output and voltage.

Solar Power of the Past

In CENTURY MAGAZINE, Dec. 1884, I found these excerpt from an article on astronomy. Harnessing the sun's energy is an idea known by the ancients. The mirrors of Archimedes burned the Roman fleet at Syracuse about 200 B.C. For other examples see page 17, Vol. 1 of THE SURVIVOR. (Burning glass, Burning mirror and Polyzoal lens.)

In this article you will see that the parabolic mirror was not only as sophisticated as modern mirrors, but a demonstrator model was actually harnessed to run a printing press. The writer, S.P. Langley, admitted that such sun engines were not economical at that time, but he predicted a time in the future would come when coal would be exhausted and solar engines would be the thing. He gave England 300 years of coal, although, at the present rate of use, it will not last nearly that long. Also, he was apparently ignorant of the fact that the projected abundance of coal is misleading, since however much there actually is, the deeper one has to dig for it, the more expensive it becomes. Consequently, if England and the rest of the world had 1000 years supply of coal, it will soon be so hard to get at and so expensive that 950 years supply might just as well be on the moon.

An interesting thing in the article is that Langley seemed to have no knowledge of petroleum, which, with the internal combustion engine, replaced the majority of coal use. Had he known of petroleum and the projected amounts of it, he might have given the world a 600 years supply of available energy. He obviously knew more about the sun and solar power than he knew of economics, population growth and its consequent drain of fossil fuel.

See also Burning-glass, Burning-mirror and Polyzoal Lens on

pages 404-405 of Survivor Vol. 1

THE SUN'S ENERGY

by S.P. Langley

One certain thing is this—that we cannot by any contrivance raise the temperature in the focus of any lens or mirror beyond that of its source (practically we cannot do even so much); we cannot, for instance, by any burning-lens make the image of a candle as hot as the original flame. Whatever a thermometer may read when the candle-heat is concentrated on its bulb by a lens, it would read yet more if the bulb were dipped in the candle-flame itself; and one obvious application of this fact is that, though we cannot dip our thermometer in the sun, we know that if we could do so the temperature would at least be greater than any we get by the largest burning-glass. We need have no fear of making the burning-glass too big; the temperature at its solar focus is *always* and necessarily lower than that of the sun itself.

For some reason no very great burning-lens or mirror has been constructed for a long time, and we have to go back to the eight-

eenth century to see what can be done in this way. The annexed figure (Fig. 8) is from a wood-cut of the last century, describing the largest burning-lens then or since constructed in France, whose size and mode of use the drawing clearly shows. All the heat falling on the great lens was concentrated on a smaller one, and the smaller one concentrated it in turn, till at the very focus we are assured that iron, gold, and other metals ran like melted butter. In England, the largest burning-lens on record was made about the same time by an optician named Parker for the English Government, who designed it as a present to be taken by Lord Macartney's embassy to the Emperor of China. Parker's lens was three feet in diameter and very massive, being seven inches thick at the center. In its focus the most refractory substances were fused, and even the diamond was reduced to vapor, so that the temperature of the sun's surface is at any rate higher than *this*.

(What became of the French lens shown, it would be interesting to know. If it is still above ground, its fate has been better than that of the English one. It is said that the Emperor of China, when he got his lens, was much alarmed by it, as being possibly sent him by the English with some covert design for his injury. By way of a test, a smith was ordered to strike it with his hammer; but the hammer rebounded from the solid glass, and this was taken to be conclusive evidence of

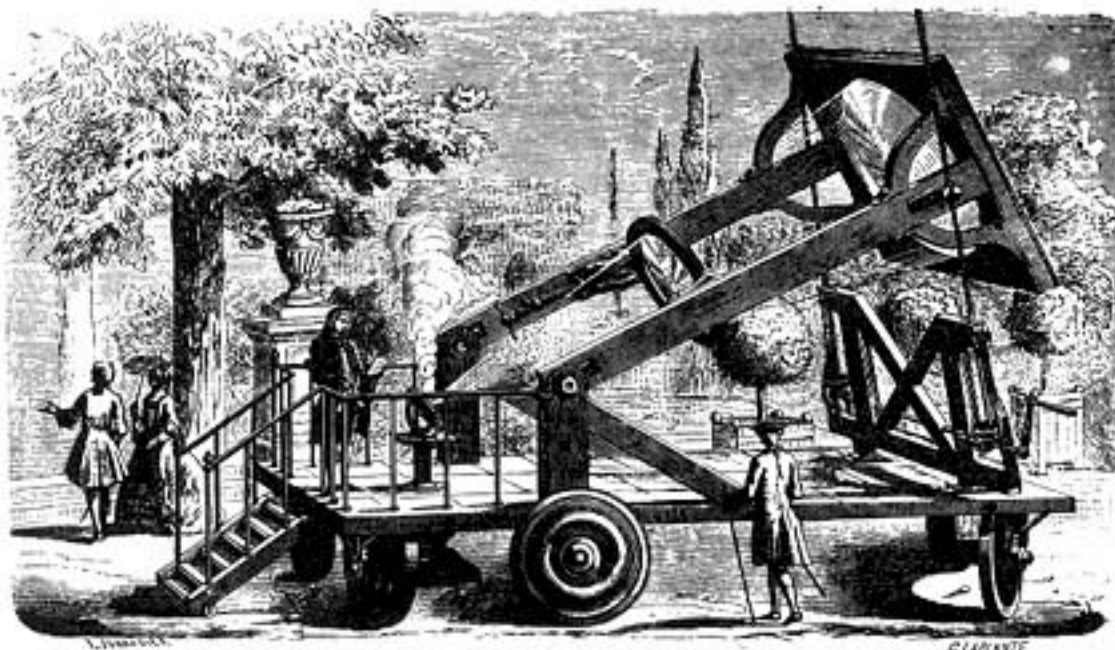


FIG. 8.—BERNIERES'S GREAT BURNING-GLASS. (AFTER AN OLD FRENCH PRINT.)

magic in the thing, which was immediately buried, and probably is still reposing under the soil of the Celestial Flowery Kingdom.)

We have, in all that has preceded, been speaking of the sun's constitution and appearance, and have hardly entered on the question of its industrial relations to man. It must be evident, however, that if we derive, as it is asserted we do, almost all our mechanical power from this solar heat,—if our water-wheel is driven by rivers which the sun feeds by the rain he sucks up for them into the clouds, if the coal is stored sun-power, and if, as Stevenson said, it really is the sun which drives our engines, though at second hand,—there is an immense fund of possible mechanical power still coming to us from him which might be economically utilized. Leaving out of sight all our more important relations to him (for, as has been already said, he is in a physical sense our creator, and he keeps us alive from hour to hour), and considering him only as a possible servant to grind our corn and spin our flax, we find that even in this light there are startling possibilities of profit in the study of our subject. From recent measures it appears that from every square yard of the earth exposed perpendicularly to the sun's rays, in the absence of an absorbing atmosphere there could be derived more than one horse-power, if the heat were all converted into this use, and that even on such a little area as the island of Manhattan, or that occupied by the City of London, the noon-tide heat is enough, could it all be utilized, to drive all the steam-engines in the world. It will not be surprising, then, to hear that many practical men are turning their attention to this as a source of power, and that, though it has hitherto cost more to utilize the power than it is worth, there is reason to believe that some of the greatest changes which civilization has to bring may yet be due to such investigations. The visitor to the last Paris Exposition may remember

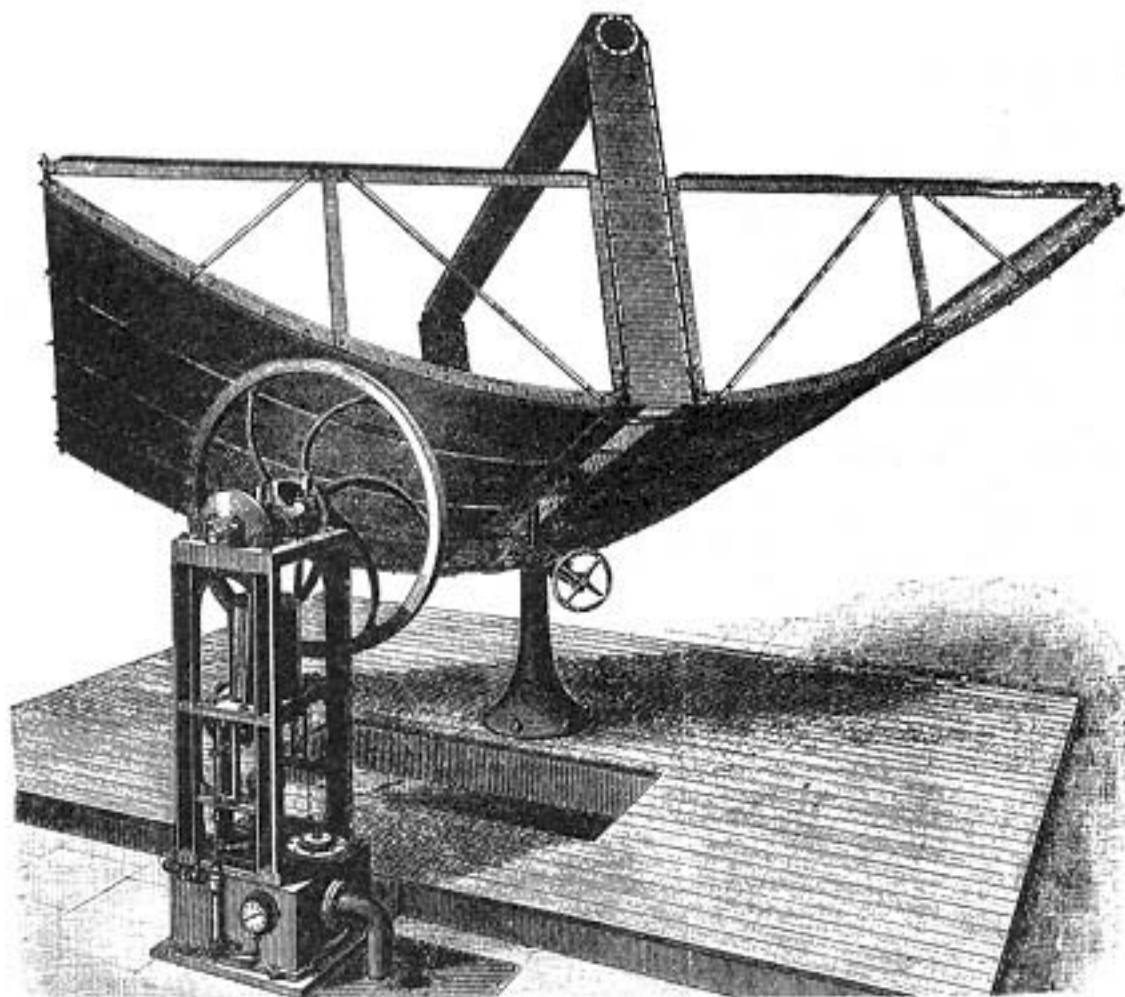


FIG. 12.—ERICSSON'S NEW SOLAR ENGINE, NOW IN PRACTICAL USE IN NEW YORK.

an extraordinary machine on the grounds of the Trocadéro looking like a gigantic inverted umbrella pointed sunward. This was the sun-machine of M. Mouchot, consisting of a great parabolic reflector which concentrated the heat on a boiler in the focus and drove a steam-engine with it, which was employed in turn to work a printing-press as our engraving shows (Fig. 11). Because

these constructions have been hitherto little more than playthings, we are not to think of them as useless. If toys, they are the toys of the childhood of a science which is destined to grow, and in its maturity to apply this solar energy to the use of all mankind.

Even now they are beginning to pass into the region of practical utility, and in the form of the latest achievement of Mr. Ericsson's ever-young genius are ready for actual work on an economical scale. We present in Fig. 12 his new actually working solar engine, which there is every reason to believe is more efficient than Mouchot's, and probably capable of being used with economical advantage in pumping water in desert regions of our own country. It is pregnant with suggestion of the future, if we consider the growing demand for power in the world, and the fact that its stock of coal, though vast, is strictly limited, in the sense that when it is gone we can get absolutely no more. The sun has been making a little every day for millions of years—so little and for so long that it is as though time had daily dropped a single penny into the bank to our credit for untold ages, until an enormous fund had been thus slowly accumulated in our favor. We are drawing on this fund like a prodigal who thinks his means endless, but the day will come when our check will no longer be honored, and what shall we do then?

The exhaustion of some of the coal-beds is an affair of the immediate future, by comparison with the vast period of time we have been speaking of. The English coal-beds, it is asserted, will, from present indications, be quite used up in about three hundred years more. Three hundred years ago the sun, looking down on the England of our forefathers, saw a fair land of green woods and quiet waters,

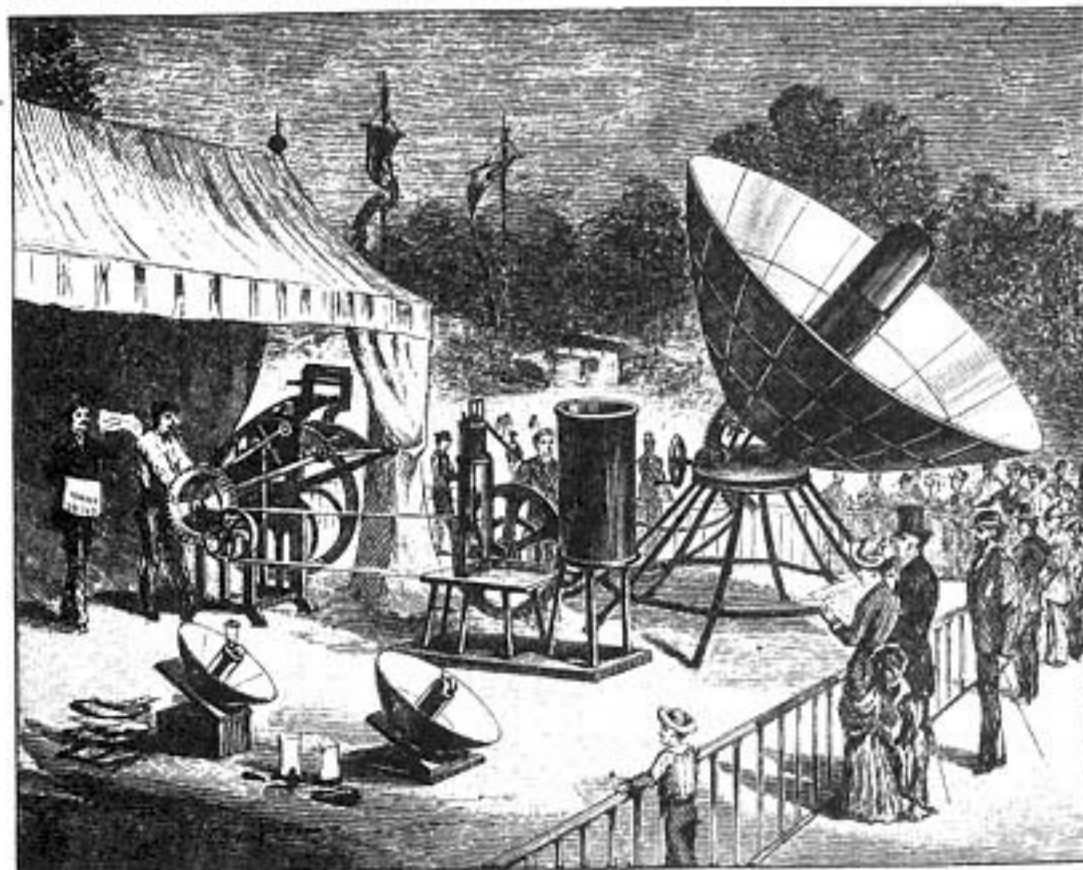


FIG. 11.—MOUCHOT'S SOLAR ENGINE. (FROM A FRENCH PRINT.)

a land unweary with noisier machinery than the spinning-wheel, or the needles of the "free maids that weave their threads with bones." Because of the coal which has been dug from its soil, he sees it now soot-blackened, furrowed with railway-cuttings, covered with noisy manufactories, filled with grimy operatives, while the island shakes with the throb of coal-driven engines, and its once quiet waters are churned by the wheels of steamships. Many generations of the lives of men have passed to make the England of Elizabeth into the England of Victoria, but what a moment this time is compared with the vast lapse of ages during which the coal was being stored! What a moment in the life of the "all-beholding sun," who in a few hundred

years—his gift exhausted and the last furnace-fire out—may send his beams through rents in the ivy-grown walls of deserted factories, upon silent engines brown with eating rust, while the mill-hand has gone to other lands, the rivers are clean again, the harbors show only white sails, and England's "black country" is green once more! To America, too, such a time, may come, though at a greatly longer distance.

Does this all seem but the idlest fancy? That something like it will come to pass sooner or later is a most certain fact—as certain as any process of nature—if we do not find a new source of power; for of the coal which has supplied us, after a certain time we can get no more.

Future ages may see the seat of empire transferred to regions of the earth now barren and desolated under intense solar heat—countries which, for that very cause, will not probably become the seat of mechanical and thence of political power. Whoever finds the way to make industrially useful the vast sun-power now wasted on the deserts of North Africa or the shores of the Red Sea, will effect a greater change in men's affairs than any conqueror in history has done; for he will once more people those waste places with the life that swarmed there in the best days of Carthage and of old Egypt, but under another civilization, where man no longer shall worship the sun as a god, but shall have learned to make it his servant.

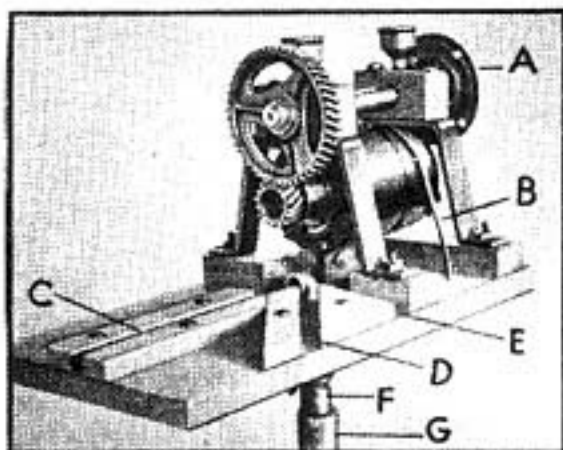
Wind-Driven Battery Charger

By L. G. HEIMPEL
(Popular Science 1933)



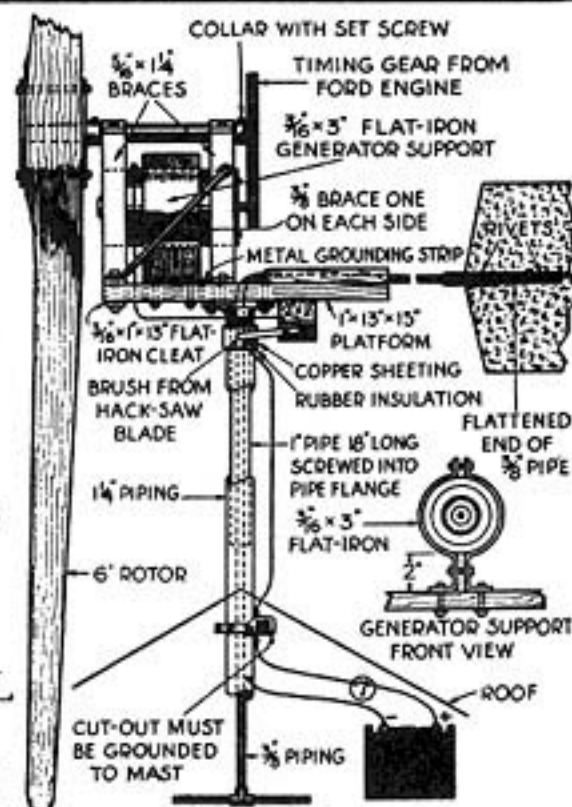
MANY thousands of farm folk are still dependent upon battery sets for their radio programs. To them the charging of storage batteries is still the greatest bugbear of the battery set. This homemade wind-driven charger is an economical solution of their problem; indeed, it is designed to take care of not only the battery of a single set but the batteries of a whole neighborhood. The farm boy who makes one of these in a community not served by high-line power can earn the cost of the plant and extra spending money in a short time.

The plant consists of a 6-volt automobile generator mounted on a turntable on a mast of piping as shown in the drawings. The generator is driven by a 6-ft.



two-bladed wind wheel or rotor which is really a propeller of the airplane type, through a 3-to-1 ratio gear drive. This is necessary to insure correct generator speeds. The plant is designed to produce a sufficiently high voltage to close the cut-out points of the generator in a wind of 10 miles an hour, though this will depend somewhat on the condition of the generator and the perfection of the workman-

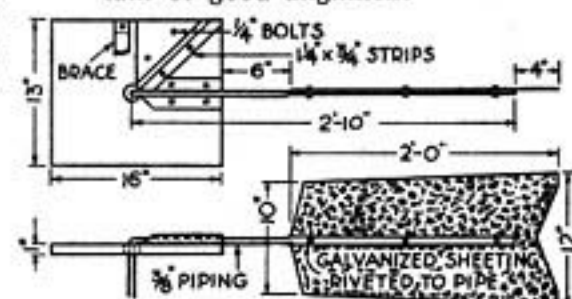
A, propeller flange; B, positive wire to sliding contact brush; C, D, E, grooves for vane bar; F and G, pipes



ship in the propeller.

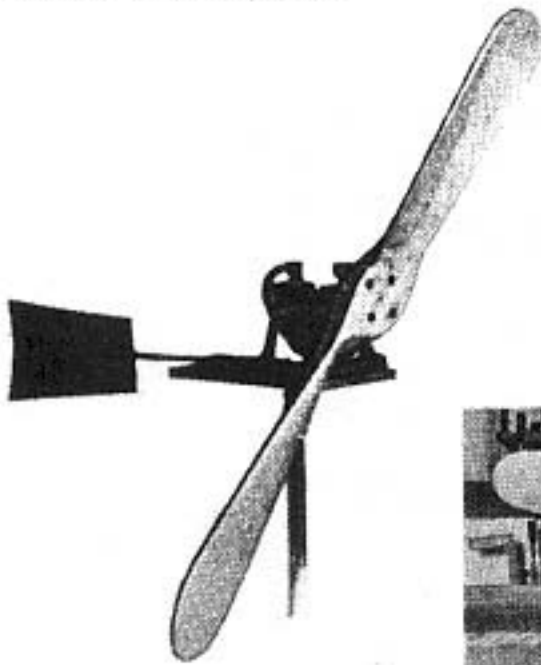
The generator may be one from a model-T Ford, a Chevrolet, Overland 4, or any light car made during

the last ten years. It must be in good condition, and the cut-out and ammeter will be needed. The brackets or supports which hold the propeller shaft are of flat iron and can be made by any blacksmith. The bearings may be of wood, if desired, though care is necessary to make certain of good alignment



The general assembly drawing, a front view of the generator support, and details of vane and turntable. The vane can be set full on, full off, or half into the wind

in boring the holes for the shaft and in mounting the bearings on the supports, otherwise there will be too much friction. Hard maple or birch blocks are best for wooden bearings, and after they are made they should be boiled in linseed oil. A piece of $\frac{7}{8}$ -in. cold-rolled steel shafting is about right for the propeller, but other sizes will do equally well.



The generator is driven by the cam-shaft gear of the automobile engine, which is mounted on the propeller shaft and meshes with the regular generator drive gear on the generator shaft. The cam gear will have to be fitted to the end of the propeller shaft in a machine shop, though this is a simple operation. With a little ingenuity a sheet metal cover can be made to protect the gears and to provide an oil bath for them. However, the writer knows of several outfits which have been running dry for several months, yet the gears show little wear.

The turntable is mounted on a 1-in. pipe flange into which is threaded a piece of 1-in. piping about 18 in. long. The inner mast is slipped into the mainmast, which consists of 1¼-in. piping. The length of this mast depends on the nature of the building.

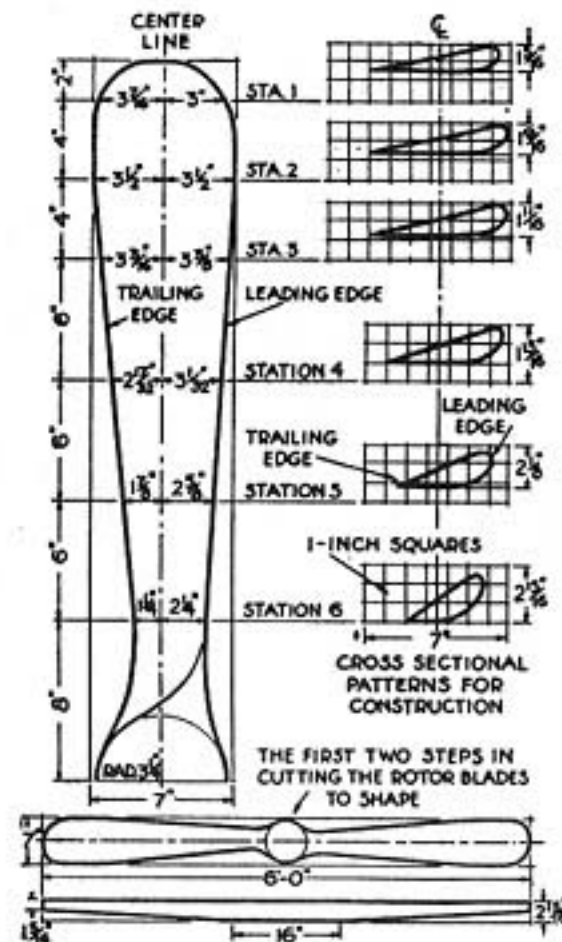
or derrick on which the outfit is to be mounted, but the design shown may be used under almost any conditions.

The requirements, of course, will vary somewhat with the circumstances under which the



How the airplane type propeller is tested for balance. A nail is driven into the center hole on each side, and these rest on two steel squares, which serve as parallels.

plant must operate. There may be some differences between the generator employed, for example, and that used in the plant described, which is from a model-T Ford. The distance between the generator and the battery should never be more than 50 ft. □



How the blades are marked out and shaped. The flat surfaces face forward into the wind

**Solar heating
from
beer cans?**

ALBUQUERQUE, N.M.
(AP) — A computer analyst at Kirtland Air Force Base here is recycling beer cans into a solar energy heating system.

"Based on my experiments," Nat Martz says, "I believe the beer can approach is the most economical method available to me. It will make it possible to eventually heat my entire house."

Martz, who works for the Air Force Systems Command's Weapons Laboratory at the air base, has spent evenings and weekends for the last two years designing, building and testing a prototype system.

It consists of a solar collector filled with 400 beer can halves and connected to an insulated bin of gravel, where the sun's heat is stored.

He cut the aluminum cans with a band saw and installed the halves with the open ends facing the sun in a glass-covered wooden box 7 feet long and 3 feet wide.

There is an open space between the cans and the glass. Heated air is drawn from there with a fan and forced into a 2-by-4-by-6-foot concrete-block bin filled with

gravel.

Martz plans to install 10 or more similar solar collectors on the south side of his sevenroom house's pitched roof and build a gravel bin 10 times larger than the present one against an east wall.

"I believe I will reduce my heating bill 75 percent by using the sun instead of natural gas," says Martz, who has collected 3,000 additional cans for the project, total cost of which he estimates will be about \$2,500.

"When the system is finished by next winter, air will be blown over the gravel to bring the stored heat from the bin into the house," he explains. "I plan to build a microprocessor computer to automatically control flow."

WORLD'S FIRST Steam-Driven Airplane

(Popular Science 1933)

*Successful Flights with
Long-Sought Craft Crown
Many Similar Attempts by
Early Aviation Engineers*

OVER the Oakland, Calif., Airport, a few days ago, a silent plane slanted across the sky trailing a thin ribbon of white vapor. Spectators heard the pilot shout a greeting from the air. They saw him flash past, skimming the ground at a hundred miles an hour. They watched him bank into a turn, slide to a landing, and, with the propeller spinning backward, roll to a stop in less than a hundred feet. They had seen, for the first time in history, a man fly on wings powered by steam!

Two brothers, George and William Besler, the former a geologist thirty-one years old, and the latter a mechanical engineer, two years younger, have achieved the dream of Maxim, Langley, and other pioneers of flight. Through their work, the steam-driven airplane, long talked about, long planned, has become a reality.

This spectacular development in the field of aeronautics is the result of three years of secret experiment. The inventors began their work in 1930, in a machine shop at Emeryville, Calif. A few weeks ago, they brought the product of their researches, a 180-pound engine developing 150 horsepower, to the Oakland Airport and installed it at the nose of a conventional Travel Air biplane.

This blue machine, with William Besler at the controls, sped down the runway and climbed into the air without a sound except the low whine of the propeller and the hum of wind through the wires. Swing-

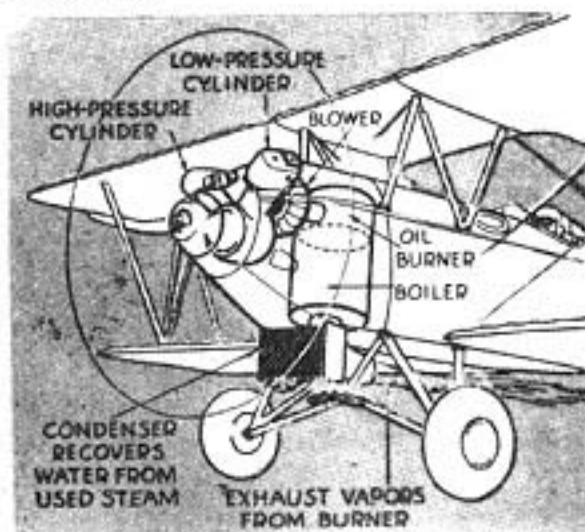
ing back over the field at 200 feet, the pilot shouted "Hello!" and heard the answering calls from spectators below. Conversation in the craft, the two inventors told me when I interviewed them a few hours after their historic demonstrations, was as easy as conversation in an open automobile.

Three times, the blue plane blazed a steam trail into the air, taking off, landing, circling about, remaining aloft for five minutes at a time. The constant, wearing vibration of the gas engine was gone; the smooth push and pull of steam power had supplanted it. Each time, as the machine swooped down and the wheels touched, Besler pulled back a small lever at the side of the cockpit and the steam engine at the nose of the ship instantly raced in reverse, whirling the propeller backward to act as a powerful brake and reduce the landing run to a minimum.

This method of slowing down, possible only with steam power plants, applies the braking effect above the center of gravity and thus prevents nosing over in a quick stop. When wheel brakes are jammed on suddenly, a plane noses over or somersaults in a ground crash. Coming in at fifty miles an hour, the Beslers told me, the new steam plane can sit down and come to a stop in a field hardly a hundred feet square.



By
H. J.
FitzGerald



Drawing shows the arrangement of the V-type engine in the nose of the Besler plane. All parts of power plant are ahead of the cockpit. At top, steam-driven plane in first flight with William Besler at controls

The engine is a two-cylinder, compound, double-acting, V-type power plant. Its high-pressure cylinder has a three-inch bore and a three-inch stroke; its low-pressure cylinder has five and a quarter-inch bore and a three-inch stroke.

Just behind the engine, the inventors showed me the barrel-shaped metal boiler which, with its super-efficient burner, explains why they have succeeded where others have failed in attempting to drive planes with a steam engine.

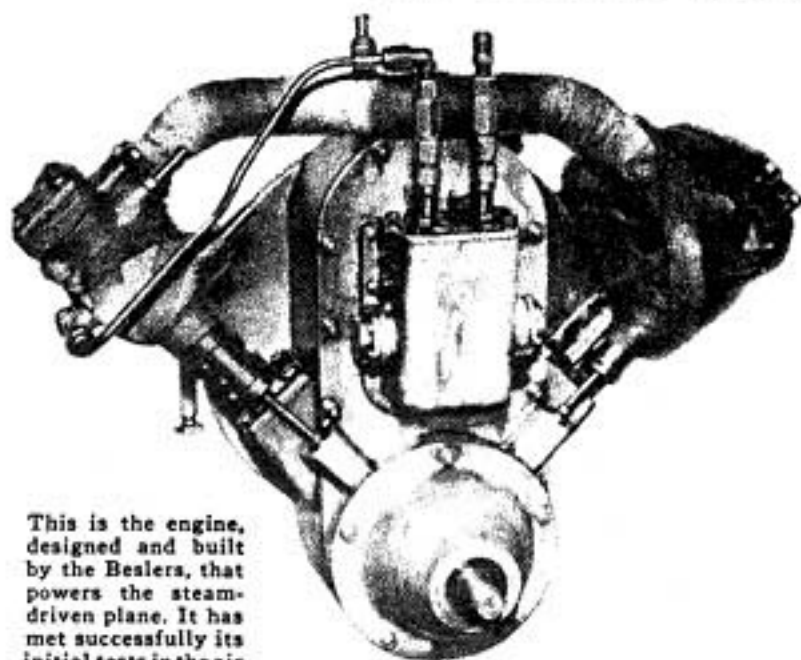
Using vaporized fuel oil, the patented burner releases as much as 3,000,000 British thermal units per cubic foot of fire-box space. This, they told me, is far in excess of anything hitherto attained. An electric blower drives this tremendous heat down among the flat spirals of a single 500-foot pipe coiled within the boiler. Three-eighths of an inch thick, inside measurement, at the bottom, the pipe gradually increases in size until it has an inside diameter of five-eighths of an inch at the top. The water supply to the coiled pipe is thermostatically controlled to keep the temperature constant regardless of pressure.

UNDER the fuselage nose is the condenser which looks like an ordinary radiator for a water-cooled motor and which is said to recover more than ninety percent of the water

from the used steam. By using a steam-feed water-pump, the inventors employ the exhaust vapor to pre-heat the feed water entering the boiler and thus decrease the time required to build up pressure within the coils.

The operation of the power plant, once it is started, is practically automatic. At the start of a flight, William Besler climbs into the cockpit and flips over a small switch. Instantly the electric blower goes into action, driving air mixed with oil spray through the burner. Here, an electric spark ignites the mixture and sends a blowtorch of flame roaring downward around the coils of pipe. A few minutes later, steam pressure is high enough for the take-off. All the pilot has to do, from then on, is to operate the throttle and reverse lever.

At 800 degrees F., the steam pressure built up within the coils reaches 1,500 pounds. With a 1,200-pound pressure, the



This is the engine, designed and built by the Beslers, that powers the steam-driven plane. It has met successfully its initial tests in the air

engine will deliver 150 horsepower, whirling the propeller at 1,625 revolutions a minute. Tests have shown that ten gallons of water is sufficient for a flight of 400 miles. By increasing the size and efficiency of the condenser, the experimenters told me, they believe they can make this amount of water last indefinitely.

As news of their sensational flights flashed to all parts of the country, eager interest was aroused among aeronautical authorities. The prospect of steam planes on the skyways opens up fascinating possibilities.

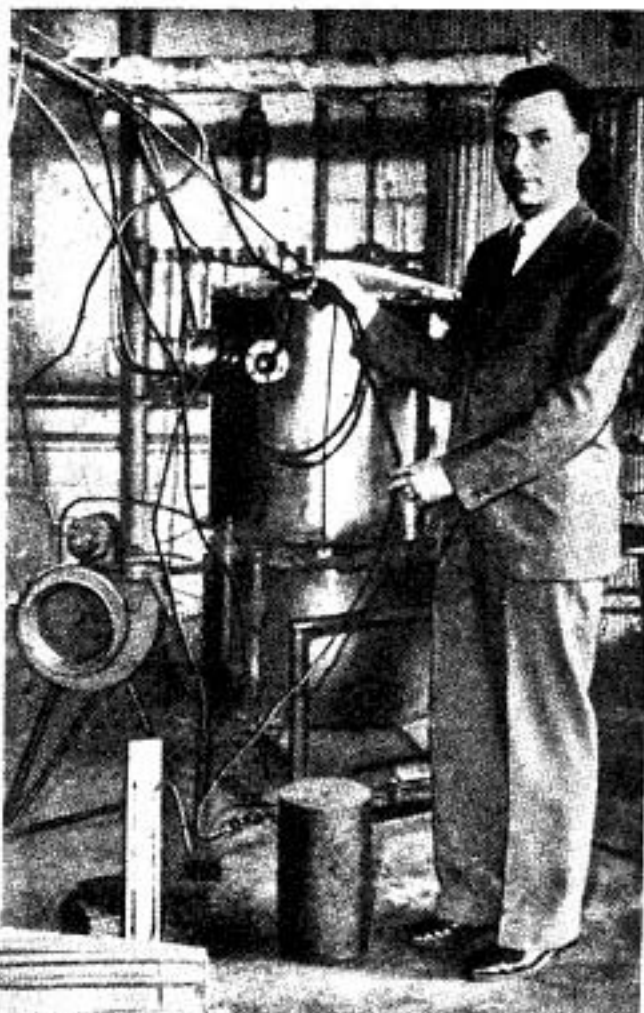
Burning fuel oil so non-explosive that it merely smolders if struck by the flame of a blowtorch, the new power plant eliminates the menace of fire. In addition, the Beslers told me, enough fuel oil for a hundred-mile trip can be bought for forty cents.

Because, above a thousand feet, steam-driven planes would be as silent as soaring birds, they would have particular value in military work. Noiseless war planes have long been sought. But muffling gasoline engines reduces their power to such an extent that the plan is impractical. The new power plant, silent by nature, would permit long-distance raids above the clouds by ghost ships giving off no telltale drone of motors to warn the enemy or to aid in directing anti-aircraft fire.

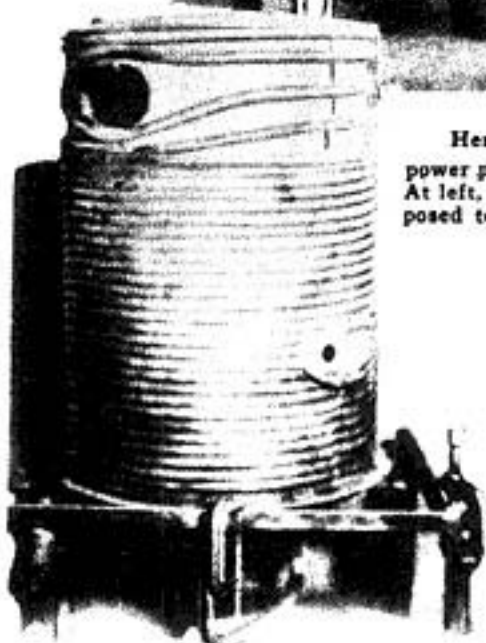
MOST spectacular of all are the possibilities of steam on the airways of the stratosphere. In the thin atmosphere of this region, ten miles or more above the surface of the earth, experts agree, the highspeed transport ships of the future will fly. Here there are no clouds, no storms, and the steady trade winds of the upper blue will increase the speed of long distance passenger, mail, and freight machines.

Already, here and abroad, stratosphere ships, with pressure cabins and variable-pitch propellers, have been designed and are under construction. Test hops have been made in such high-flying experimental craft in France and Germany. The chief stumbling block at present is the gasoline motor. It steadily loses power as it ascends. Climb to 20,000 feet and a motor that delivers 150 horsepower at sea level will retain only half its power. Spiral on up to 30,000 feet and your engine will have but three-tenths of its sea-level horsepower. And you are then only half way to the stratosphere!

Now consider the steam engine. It loses no power at all with altitude and *gains in efficiency the higher it goes!* This is because the pressure on the exhaust is less in thin air than at sea level. Thus the perfection of the flying steam engine is a vital step toward conquering the stratosphere.



Here is William Besler preparing power plant for test run in workshop. At left, the interior of the boiler exposed to show coiled pipe used in generating steam



Superchargers, driving a blast of air into the carburetor to make up for the reduced pressure in rarefied atmospheres, help these gasoline motors. They are heavy, however, adding to the weight of the plane, and they never completely prevent loss of power at high altitudes.

This picture was made when, for the first time in the world's history, a steam-driven plane successfully flew with a man at the controls



Realizing these facts, inventors in various parts of the world have been working toward the goal achieved by the Besler brothers. In Akron, Ohio, last fall, a local inventor, Harold C. Johnson, announced the completion of a steam engine with two opposed cylinders, weighing, complete with boiler, only 146 pounds.

Some months earlier, it became known that the Great Lakes Aircraft Company, at Cleveland, Ohio, was working upon an experimental steam-driven biplane. Recent dispatches from France reported that a Paris mechanic had perfected a light steam power plant for airplanes. Another news item, coming from Sweden, told of steam-turbine engineers who are working on a new-type turbine for aircraft use, while a third, from Italy, carried the information that G. A. Raffaelli, an aeronautical engineer, had announced a steam engine for stratosphere machines.

But it was the two California inventors, carrying on their secret researches, who first achieved the long-sought goal of steam-driven flight.

Ever since Henri Giffard, in 1852, navigated the air in the world's first dirigible, creeping along near the outskirts of Paris at seven miles an hour propelled by a clumsy three-horsepower steam engine weighing 462 pounds, there have been proponents of steam power for aircraft.

Many of the pioneers of flight, before the perfection of the gas engine, sought to fly by steam. In 1894, Sir Hiram Maxim, the English inventor, spent \$200,000 building a gigantic multiplane weighing 8,000 pounds and having a wing area of almost 4,000 square feet. Driven by a 363 horsepower steam engine and two eighteen-foot propellers, the giant craft reached thirty-six miles an hour on special tracks built to hold it down during the preliminary tests. Its lift at this speed was so great that it tore loose from the tracks, crashed over on one side, and demolished itself.

Two years later, Samuel Pierpont Langley, secretary of Smithsonian Institution, Washington, D. C., saw his sixteen-foot model fly for half a mile above the Potomac River propelled by a miniature, seven-pound steam en-

STEAM TURBINE TO RUN NEW AIRPLANE

Popular Science December 1931

Capt. H. C. Richardson with a model of his steam-driven airplane now being built at Cleveland. At right, note turbines behind the propellers



tages of a 2,500-horsepower steam-driven plane would be the enormous load of passengers or freight that it could carry. Absence of noise, vibration, and fire hazard are others. Steam heat from the turbines may be used to make the passenger cabin comfortable in winter. Far from a dreamer is the designer of the aerial locomotive—Capt. Holden C. Richardson, U.S.N., retired. He has served as chief engineer of the Naval Aircraft Factory and as head of the Design Branch of the Naval

BEHIND the closed doors of a one-story brick building at Cleveland, Ohio, plans have just been completed for an amazing 2,500-horsepower airplane to be driven by steam. At this writing its construction was about to begin. No fanciful project is this, for it is sponsored by one of the country's leading makers of aircraft. Navy officials interested in the plane's military possibilities will take charge of the first tests when it is completed soon. This marks the first serious attempt to apply steam power to a plane since Samuel Pierpont Langley's ill-fated "aerodrome" dove into the Potomac River in 1903. When the unreliability of steam power plants doomed early airplanes to failure, inventors turned to internal combustion engines to drive their flying machines. Modern lightweight alloys, unknown in Langley's time, have made possible a radical new type of steam turbine not too heavy for a plane, according to engineers of the Great Lakes Aircraft Corporation, who are building the latest craft. They have high hopes that return to steam power may lead to a revolution in airplane design, both for military airplanes and huge commercial transport planes. Chief among the advan-

Bureau of Aeronautics. He designed the Navy's famous NC seaplanes that crossed the Atlantic in 1919, piloting one of them on the flight himself. As technical adviser to the Cleveland concern, he convinced its officials that a practical steam airplane could now be built. To POPULAR SCIENCE MONTHLY he has revealed some of the striking details of the craft now projected. Outwardly the steam airplane reveals little of its unusual construction. Its lines are patterned for the most part after present-day planes. But within the fuselage is a boiler where the steam is generated. The fuel will not be shovelfuls of coal, such as popular imagination might connect with a steam power plant, but oil of a cheap and economical grade. Steam from the boiler will run two high-speed turbines on the wings, one behind each propeller, and will then pass through condensers between the turbines and the fuselage. Since the recovered water is used over again, only thirty-eight gallons are required. Oil and water are supplied to the boiler automatically; no "aerial fireman" is needed. The pilot controls the plane's speed simply by operating one throttle for each turbine.

engine, developing one and one-half horsepower. The full-sized tandem monoplane which Langley patterned after this model in 1903 and which was broken in launching, carried a gasoline motor instead of a steam power plant.

After 1903 and the success of the Wright Brothers, steam power for aircraft was practically lost sight of. Gasoline engines made such rapid advance in lightness and reliability that they came into universal use in aviation.

Recently, however, the advantages of steam power have again been attracting an increasing amount of attention.

With the first experimental machine already climbing into the air at Oakland, steam has, at last, been harnessed to work in the sky. Experts are watching the progress of the inventors with the keenest interest. Their machine is a definite step toward the huge, winged steamers of the sky visioned by pioneers of flight.

THE WOODSTOVE — A BIG STEP TOWARD SELF SUFFICIENCY

By Jim and Stephanie Watters

It was probably the coldest week of last winter. I mean it was COLD. Without any advance warning, all the electricity in the area went out. In a matter of hours the happy young suburbanites in their nice new homes were hurting. Do you know what it's like to wrap your baby in so many blankets he looks like an Eskimo but his little face is still grey with cold? Our friends found out how vulnerable they were. Those who didn't have electric heat had furnaces that were fired by electricity and/or depended on electric fans to blow the heat into the house.

A few tried to make do with their fireplaces. The whole family crowded

around the hearth, freezing on one side and roasting on the other. Supper consisted of burnt hotdogs and marshmallows. Bathing was out of the question, which the kids didn't mind too much. So was washing the dishes. And I could go on describing the hardships and inconveniences our friends went through during that power failure, but let's don't do that. Ask yourself seriously: "How bad would it be on my family and me if all the electricity went off for a day or two during the winter?"

The next question of course is, what can I do about it? My suggestion is that you get a woodstove just as soon as you can. By woodstove, I do not mean a wood-burning range. The wood-burning ranges are not the answer, but a modern woodstove such as a Fisher, Jotul, Timberline, Gibraltar, etc. is the answer. These super-stoves are 3-4 appliances in one: heater, cook stove, fireplace, and trash burner. Get a big metal dishpan and it's also a hot water heater!

Last year when we were building our house, I made a deal with the general contractor. I traded my labor and insulated the whole house in return for a simple flue (chimney). It was one of the best investments I ever made. Then I worked out a deal for a good woodstove—a Fisher Mama Bear. Because of FHA financing requirements and insurance worries, I let the contractor put in electric heat, but the cold winter we've been having this year has proved it certainly is not needed—our woodstove is more than sufficient.

The Fisher stove is attractive and does not smoke up the house. That makes my wife very happy. It heats our whole house very nicely and uses so little wood you wouldn't believe it. That makes me very happy. It has two individual cooking surfaces with different temperatures and will cook a delicious pot of beans or stew. Because of the unusual way it's built we can leave the house or go to bed knowing we'll still have a fire in the morning because it holds fire up to 24 hours. And here's the two best parts: I haven't cut any wood all year except for a little kindling. I'm a carpenter and my Fisher does fine on the scraps that I bring home from the job. (Lousy pine no less!) Second, my woodstove will more than pay for itself the first winter with the money I save on my heating bill.

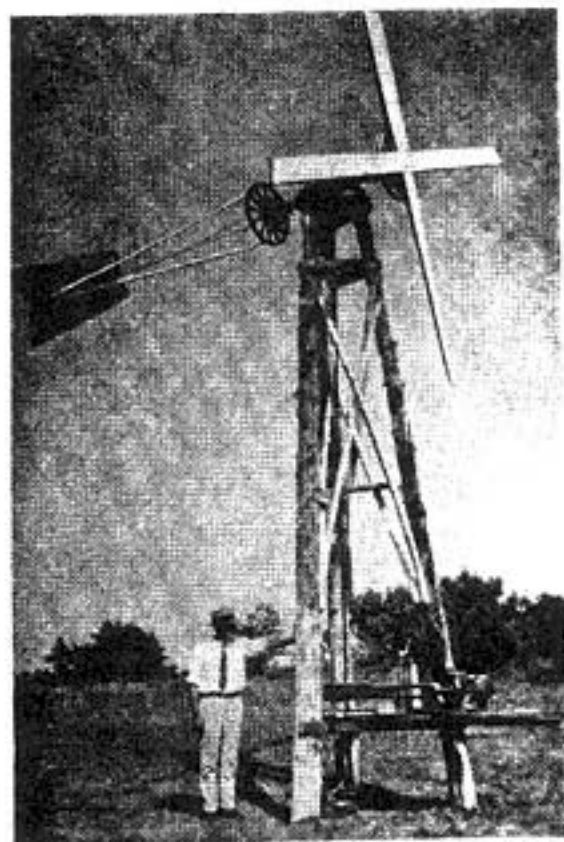
But of course, Fisher is not the only

modern woodstove that you should consider. There are a lot of good ones on the market now. Just glance through a copy of THE MOTHER EARTH NEWS and you'll see several. FISHER, TIMBERLINE, JOTUL, GIBRALTER, SIERRA and THE EARTH STOVE are just some of the better stoves. Choose one that has heavy steel welded (not bolted) construction with fire-brick lining.

Forget the Franklins! They may seem like a good bet because they look less expensive at first. But don't forget to figure on the high-priced 8 or 10 inch flue pipe, and a pipe adapter, and the screen which is usually extra, and the big 8" or 10" elbows which you may have to order special. If the wife still insists on a Franklin just because she thinks it's better-looking, just remember we warned you. I've never seen a Franklin that didn't smoke when the doors were open. And if you close the door, you lose the fire-light which is the only good thing I know of about a Franklin. With the doors closed a Franklin is just a third-rate wood heater. It's never air-tight so you can't control the fire. It puts out less heat per pound of wood consumed than any of the modern woodstoves. During emergency conditions of course, it is a lot better than a fireplace, but if you're going to be adequately prepared, you'd be better off with a small modern woodstove than the biggest Franklin fireplace.

"Okay, Jim," you say. "You and Stephanie have convinced me. I'd love to get the utility company off my back and get a good woodstove, but man, I don't even have a chimney. What can I do?" Well, good chimneys are a must, especially with older-type woodstoves and heaters. What you can do depends on the type of house you have and how ridiculous your local building codes are. It pays to be careful with your chimney arrangements, however. With a modern woodstove properly installed there is almost no chance of a fire starting from inside, but the best stove in the world can be hazardous if connected to an improper chimney. Good chimney design is vital for both safety and proper heat. I have connected brand new heaters to brand new chimneys that were so poorly constructed that they would not draw. The heater wouldn't even burn hard wood blocks soaked in kerosene. Yet we took the same heater right next door and it would burn big green oak logs. The difference was all in the chimney.

Do a little reading about chimneys before you build one. You might decide to use one of the pre-fabricated chimneys. There are good ones available now that are really safe and fairly inexpensive. I've installed some in modular homes, and now



MAKES WINDMILL GENERATOR WITH CAST-OFF AUTO PARTS

Popular Science Monthly, August 1936

A NOVEL homemade windmill generator that cost less than three dollars utilizes the rear end and differential gears salvaged from an old auto. Twelve-foot blades are fastened to one of the car wheels, and the assembly is mounted on a rotating support on top of an improvised tower. A rudder projecting from the second wheel keeps the blades facing into the wind, while an eighteen-foot shaft connected into the differential drives a small generator.

there is even a kit for installing them in double-wide trailers. Once I would have refused to recommend any type of wood heat in a mobile home. But with the new improved chimney kits and proper insulation they are safe and very economical. I still don't recommend any type of "tin heater" in a mobile home, or really any home. Although useful and fairly safe in the hands of an old-timer, I don't think novices should fool with them. They can be very dangerous. Besides, they don't last long. They burn out in one or two seasons, and since most of the heat goes up the chimney, they quickly burn out connecting pipe, too. Also, they require much more shielding and take up too much room since they have to be at least 36" from any combustible wall or furniture. In contrast, my Fisher requires much less space and shielding and is guaranteed to never burn out for as long as I live.

So get a good modern woodstove. If you don't have a good chimney, install one of

the quality chimney kits, or call a brick mason. Around here, you can have a simple flue run for about the same price you'd pay for a good high-powered rifle. It's worth it. Stop and think: under any survival conditions my immediate needs are food and water, shelter and clothing. Having a good woodstove set up in your home would provide a way to do some serious cooking, sterilize water by boiling, make your shelter liveable in cold weather, and dry your wet clothes in bad weather. And unlike your arsenal of defense-rifles and pistols, your woodstove begins to immediately pay for itself. In less than one year, you should get your money back out of the stove, and the next year of use should more than pay for your chimney. As much as I like my guns, I really can't say that about them.

Here's one more good thought about Fishers, Timberlines, etc. in a post-collapse situation. A Fisher weighs up to 435 pounds and a Timberline may weigh up to 588 pounds. If your home is ransacked

by looters they may take your food, your guns, your hand tools and so on, but it's doubtful that they're going to try to run off with your heavy woodstove.

So there you have it—an item that would be indispensable under emergency conditions that is also a great money-saver that you can enjoy right now. It's a good investment because any way you look at it, in practical terms of usage or just dollars and cents, the value of your woodstove will increase every year. It will require very little labor to operate; it won't break down or wear out. And as I said, it isn't the kind of thing a roving band of scavengers would try to rip off.

If for some reason you just can't get one of the superstoves now, do try to get or make a wood heater of some kind that has a surface you can cook on. A little looking around during the summer should find you a good deal on a used one. Make some kind of woodstove a priority item on your list of survival preparations. The woodstove is one big step toward self-sufficiency.

EMERGENCY LIGHT, HEAT, ETC. FOR A CITY APARTMENT

By Professor Rufus J. Firefly

As a veteran of two city-wide blackouts and innumerable local power failures, I've come to appreciate the need for auxiliary light, heat, and communications in an emergency/survival situation. Living in a New York City apartment puts me in a unique situation. In selecting equipment for my basic needs, I've tried to keep in mind safety, convenience, availability, and fuel cost.

LIGHT: My initial choice was a

Coleman lantern. Since most of their models operate on gasoline, I was reluctant to store a potentially explosive fuel in an apartment. I chose the Model 201, which is fueled by kerosene. Several manufacturers, including Coleman, offer lanterns which run on bottled propane (LP gas). I ruled out their use because of cost and availability. Also, a faulty cartridge could present a hazardous situation. The kerosene-powered Coleman works on the

same principle as the gasoline ones. One pumps the lantern to pressurize the fuel, which in turn illuminates a silk mantle. The only difference with the Model 201 is that the mechanism must be pre-heated with a bit of alcohol. This requires the storage of a quantity of alcohol, but the amount needed is so small as to almost negligible. Once the Model 201 gets going, it will burn for 8½ hours on one filling. Occasionally, one must pump the lantern when the pressure gets low. Spare parts are readily available. I keep on hand an extra generator and some silk mantles, which takes very little space.

The only criticism I have of the Coleman

GARBAGE-FURNACES. 1889

ONE of the most valuable papers lately presented to the American Public Health Association was that entitled "Garbage-furnaces and the Destruction of Organic Matter by Fire," by S. S. Kennington, M.D., President of the Minneapolis Board of Health. He described the Forrester garbage-crematory in use in Milwaukee, the Ryder in Pittsburgh, the Mann in Montreal and Chicago, and the Engle in Minneapolis, Des Moines and Coney Island. This latter style of furnace has just been completed at Milwaukee, and was put into operation for the first time during the session of the association. Health-officer Clark of Buffalo described the garbage-crematory in use in that city, and said that its entire running expenses were defrayed by the lubricating oils extracted, alone; so that even if no market could be found at times, or at all, for the resultant fertilizers, they might at least be used as the furnace's fuel, and thus save coal.

FIFTY YEARS AGO, there were 131 windmill manufacturers in the United States and 6.2 million windmills pumping water all over the country.

Today, there are only three windmill companies left in America—Dempster in Beatrice, Neb.; the Heller-Aller Co., producers of Baker Windmills in Napoleon, Ohio, and Aero-motor, Conway, Ark.

Rasmussen estimates there are approximately 240,000 windmills still scattered across America that can be refurbished and put into top running condition.

"Two quarts of oil and \$150 will put most of them back working," he said.

Business is booming for the three windmill companies, and sales are five times what they were a few years ago—4,000 new windmills sold throughout the United States last year compared with about 800 in 1974.

Rasmussen's windmill course lasts two weeks and costs \$195 to enroll.

Los Angeles Times Special

lamps is that the light is quite intense and glaring. I solved this by having the globe sandblasted, giving a frosted effect which makes for a softer illumination. If you decide to frost the clear globe of the Model 201, leave a dime-sized patch of transparency in order to observe the initial pre-heating phase of the operation. Coleman also offers an amber-colored globe so that insects are not attracted to the light. A side effect of the Coleman lanterns is a constant hiss due to the fuel being under pressure. This is a minor point, but in a small apartment the noise can be annoying.

Later on, I came across the line of Aladdin lamps. These lamps provide all the good points of the Coleman 201, i.e., kerosene operation and mantle-produced light. But the Aladdin goes one better by eliminating the need to pressurize the fuel. In comparison, their light output is not as bright as the Coleman's, but these lamps were designed for indoor use. Their noise-free operation and warm glow are indeed comforting when the whole city is in darkness. The only accessories needed for lifelong operation are a few extra mantles and some wicks. The Aladdin lamps are available in several styles for tabletop operation, hanging, wall-mounting, etc. I have two Aladdin lamps. I've also purchased a clear glass font so that the level of kerosene can be observed, although I've found that one can tell the amount of fuel available by simply lifting the lamp and judging by weight. Aladdin lamps are somewhat expensive. I ordered mine directly from the manufacturer. Whatever the model, Aladdin provides a full compliment of replacement parts.

I might also mention the so-called "hurricane" lanterns available in hardware and department stores. The only light produced is from a broad flame; the output being equivalent to that of a large candle. These are hardly the thing to depend upon as a sole source of emergency illumination.

Concerning battery-powered lanterns; they tend to be a somewhat expensive form of lighting. Also, the special, heavy-duty batteries which most of them require are not readily available. But most important, batteries deteriorate in time and it's all too easy to forget to keep an inventory of fresh ones on hand. During the last Big Blackout in New York City, most shops were closed when the lights went out, and the only batteries available were what one had in reserve. The next day found opportunists peddling batteries on streetcorners at scalper's prices. I do keep two flashlights on hand, my favorites being the heavy-duty Kel-lites. These are

made of aircraft aluminum and are supposed to be designed for law-enforcement personnel. They can take a lot of abuse and can also double as truncheons when you are walking darkened and potentially dangerous streets. They come in several models which use "C" or "D" cells. For around the house, I have a few Duracell 805 compacts. These run on size "AA" batteries and are quite light and pocketable. Battery power is probably the safest one can select. If this safety factor is paramount in your choice of an emergency lighting arsenal, you might look into lithium batteries. NOTE: When purchasing any battery-powered equipment, try to select items whose cell size is compatible with what you already have on hand. That way, you're not required to keep an inventory of "C", "D", "AA", 9-volt cells, etc.

LITHIUM BATTERIES: These cells are available in both "C" and "D" sizes. The only source of supply I know of is Mountain Safety Research (MSR) in Seattle. Lithium cells have a 6 to 10 year shelf life and retain 96% normal capacity at 20°F. (Alkaline batteries have only a 15% capacity at that temperature). Secondly, the voltage output is constant for over 90% of a lithium cell's life. The voltage per cell is 2.7 volts, almost twice that of a standard battery. In practical use, dummy cells are used to take up the space in flashlights, etc., that standard voltage cells would occupy. As with all batteries, the practical output life in use is variable, depending on the type of bulb utilized. For example, if you use the two lithium cells, you'll get a total of 5.4 volts. Such being the case, you can use bulbs originally intended for a four-cell flashlight. With a PR-12 flanged bulb, you'll get eight hours of constant output with 2.2 candlepower. Naturally, various bulbs will provide different light output and battery life. The drawback on lithium cells is the cost. One "C" cell retails at \$6.65 each; a "D" cell at \$9.30. Another problem is that lithium cells give off a minute amount of sulfur dioxide gas, about one milligram per day. The result can be the formation of a non-conductive film over metal contacts, so care must be taken if one decides to install them in radios, CB equipment, etc.

HEATING: During a power loss the lights go out, and chances are that heating will no longer be available. In most apartment buildings, the furnace is electronically controlled. There are several catalytic heaters available on the market, but again, I feel their shortcomings are in the fact that they use gasoline or a similarly dangerous fuel. Propane (LP gas) heaters are also sold,

but their expense and potential hazards have been previously discussed. For heat, I searched for something which would run on kerosene. I finally settled on an Aladdin "Blue Flame" heater. Operation is simple, with no need to pressurize the fuel tank. Parts and maintenance are no problem, a large cotton wick being the only item which will eventually need replacement. Aladdin offers several models of kerosene-powered heaters with various heat ratings, but their most popular one appears to be the Blue Flame which will heat up to 3000 cubic feet with 5870-9320 BTU's per hour. Burning time is 16-25 hours on a tankful of 1.3 gallons. As an added convenience, once can even cook on the top of the Blue Flame. The reputation of the product is well attested to and appears to be well made.

RADIO & TELEVISION: Needless to say, in the event of a power emergency, the old Atwater Kent and the Big Eye will give up the ghost. It's comforting to know how the outside world is faring and even enjoy the pleasure of music during times of stress. My favorite battery powered transistor radios are the multiple-band receivers, which not only provide AM and FM reception, but also pull in Public Service broadcasts and even Short-Wave. Some of the larger models run on "D" and "C" cells, which can be an expensive proposition if your receiver requires five or six batteries and you use the Alkaline type. One unit is the Panasonic RF-1005. This receiver is powered by 4 "AA" batteries, their cost being low compared to other sizes. Not only does the RF-1005 give AM and FM listening, it also receives VHF-Public Service transmissions so that one can keep tabs on what the Police and Fire Department are doing.

The absolute luxury is a battery-powered television. I have a Panasonic TR-555, which is 100% solid-state with a 5-inch diagonal screen. It's powered by nine(!) "D" cells which provide up to five hours viewing time (Alkaline batteries will give up to 12 hours viewing). It's black and white, but you get both VHF and UHF. The TR-555 can also be powered by 120-volt AC or car/boat battery. Several manufacturers have come out with battery-powered television sets. In time of national emergency, it's doubtful that many television stations will be transmitting.

COOKING: As with most apartment dwellers, I have a gas-type range. There are several models of camping-type stoves which use gasoline or propane (LP gas) fuel, the most notable being the Coleman line. As outdoor cookers, they appear to be excellent. Since my lighting and heating arrangements are based on

kerosene, I decided to choose a compatible cooker. I finally came across a line of kerosene-powered stoves. These are made by the Swedish firm of Optimus, which has provided portable stoves for several expeditions. They offer two models, the 111 and 000, both having a fuel capacity of 7/8 of a pint and a burning time of two hours. Both function with a pressurized fuel source and must be primed with a bit of alcohol. An odd thing about the Optimus products is that essential parts are finely crafted, while the nonessential ones are a bit shoddy. Operation is easy and reliable. It boils water pretty quickly. It'll make soup, coffee, fry eggs, and, if needed, melt snow for water supplies. Another cooker is one manufactured by Mountain Safety Research (MSR). These stoves are designed primarily with the mountaineer in mind. They are compact, light and will run on various fuels, including gasoline, kerosene, alcohol, naphtha, benzine, etc.

WATER: If you live in a high-rise building, it's likely that you'll be without

water, since auxiliary pumping (electrically operated) is needed to bring the supply to great heights. Fortunately, the hydrants will probably be working, so the only difficulty is carrying quantities of water up to the apartment. There are several folding water jugs available which hold up to five gallons each. Since they take little space when collapsed, it's a good idea to keep a few on hand. Just don't overdo it with a large size; water can be damn heavy!

FUEL SHORTAGE: I prefer to store small quantities of kerosene in Sigg bottles. These seamless aluminum containers are made in Switzerland and have leakproof nylon caps. They are available in both pint and quart sizes. As an accessory, Sigg offers a "filling cap," i.e., a cap with a tube-type nozzle to make emptying easier and more directional. I've improved on the Sigg cap by extending the pouring spout with a small length of plastic tubing. **CAUTION!** Keep away from the look-alike bottles from Taiwan. They are junk! Another important safety factor concern-

ing the use of kerosene and any other fuel indoors is adequate ventilation! Since all of the devices previously discussed use an open flame of one sort or another, make sure that enough air gets into the apartment! An open flame consumes oxygen.

Suggested sources of supply

Aladdin Industries, Inc.—Heating & Lighting Division, P.O. Box 7235, Nashville, Tennessee 37210.

Mountain Safety Research (MSR)—631 South 96th Street, Seattle, Washington 98108.

The Coleman Company—Wichita, Kansas 67201.

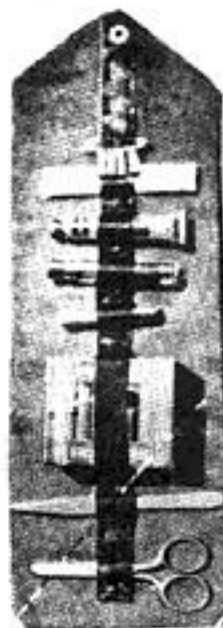
Optimus—1243 East Florence Avenue, Santa Fe Springs, California 90670.

Safariland* (Kel-lite flashlights)—1941 South Walker Avenue, Monrovia, California 91016.

*Safariland appears to be the exclusive distributor of Kel-lites, although I've seen them for sale in camping and police supply stores. Safariland is s-l-o-w in processing orders and they extract rather high handling charges.

First-Aid Kit

PREVENTS SUFFERING
ON THE TRAIL



The unrolled kit and its case, which is attached to the belt as shown at the right



Popular Science 1933

By

Leonard F. Merrill

Expert woodsman and Maine guide

THE man wise in the ways of the woods does not take chances with his health when it can be avoided. A little accident—the scratch of a thorn or the prick of a fishhook—if not attended to, may be the cause of very painful and even fatal ailments such as blood poisoning or gangrene.

A drug store is not found at every turn of a woodland path, and you will look behind many trees before you find a doctor,

so the wise man prepares for emergencies before he hits the trail for the country beyond the edge of civilization.

The emergency or first-aid kit to be described was assembled by the author and has proved, after several years' experience, to be all that is required for minor accidents and common aches and pains. It is compact, light, and complete, and the hunter and fisherman will do well in making himself one like it.

Contents of Kit. The first step in making the kit is to assemble the following: Blunt-pointed scissors and sharp-pointed tweezers; a commercial first-aid

kit containing mercurchrome (or iodine), absorbent cotton, gauze, and adhesive tape; a salve

for burns of the unguent type; laxative pills, safety pins, applicators made by winding cotton on round toothpicks and wrapping them in paper, and toothache gum or wax.

Materials. A piece of thin leather (or canvas) as wide as the tweezers are long and about 15 in. long; another piece of the same material 1 in. wide and 18 or 20 in. long; a piece of leather (or canvas) somewhat heavier than the other and about 14 in. square.

The Kit. Place the scissors at the lower end of the thin piece of leather and make a loop over them with the narrow strip by sewing the strip onto the other leather close to the sides of the scissors. Leave about 1 in. between the scissor handles and the tweezers and make a loop for the tweezers. The narrow strip of leather need not be cut between each of the loops, but may be sewed to the backing piece of leather. The first-aid kit in its cardboard container comes next, followed by a vial of the laxative pills, toothache gum, unguentine, applicators, and safety pins.

After all loops have been made, insert the articles and fold the kit. To fold it properly, the lower or scissors end should be folded up first until it is snugly over the top of the first-aid kit; then the other end is folded

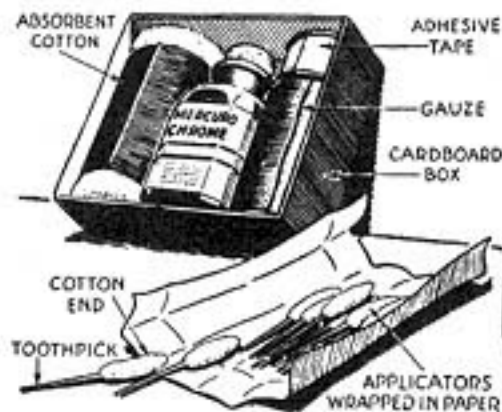
on top of that. The top or safety-pin end is now measured and cut off, leaving room enough to put a glove snap fastener on it. Put the top half of a snap fastener on this top end, and after it is in place mark the position of the lower half of the fastener and put that on. This completes the kit except

for a little trimming at the corners as shown.

Carrying Case. Place the folded kit on a piece of paper and mark around it to make a pattern the correct size. After marking around the kit in the first position, turn the kit up on its edge and mark around it again. Be sure that the lower bottom edge is on the same line that it was in the first marking. Do the same to both ends and the top

edge, placing the kit back in the first position and then turning it to the new position before making each tracing. To the top edge, which is to be the cover, add a length equal to one half the width of the kit. On the sidepieces or ends add about $\frac{3}{8}$ or $\frac{1}{2}$ in. to allow for the seams. On each side of the top, add $\frac{1}{4}$ in. so that the cover will project slightly over the sides when the case is finished.

In sewing the case, the bottom of the end piece is sewed to the middle piece first, then the other end is sewed all the way up, and finally it is necessary to go back to the other end and finish that. The case may be



The box, which contains antiseptic, cotton, gauze, and tape, is purchased. The applicators are prepared at home.



The first step is to sew a narrow strip to the main piece of thin leather in such a way as to form loops to hold the various articles. Above: Sewing the case with aid of awl. Waxed thread well pointed at both ends is required for this.

riveted instead of sewed if you so desire, but it will stand more abuse if sewed.

Cut two slits in the back of the case long enough to accommodate the belt and about 2 in. apart. Put the top half of a glove snap fastener in the cover piece and the lower half in the front, and the whole job is finished.

If you are expecting to travel in a section of the country that has poisonous snakes, you should include in your kit one of the small, flat snake-bite outfits that are sold ready made up. These are obtainable at most drug stores in the snake section and can be included either in the kit itself or carried in the case with the kit.

A QUACK DOCTOR WILL BE BETTER THAN NO DOCTOR

by Fred Bilello

As most of us know, the armed forces train enlisted men to perform routine maintenance on the troops. They mend broken bones, heal gunshot wounds, and can diagnose and treat most common ailments. Since they are not real doctors, the troops often refer to them as "quacks." There is nothing derogatory by saying this to them. It is just using a technicality with respect.

In civilian life, it is against the law to practice medicine without a license. You have to go to school for years on end so that you can have a complete knowledge of modern medicine; and also to justify your outrageous fees.

In the near future, however, things will be quite different. The world is rapidly approaching an era of chaos, and doctors that are not murdered and looted by drug addicts will soon run out of supplies. Whole regions may be uninhabitable for years, and you may be in an isolated area where no medical services are available.

It would be a good idea, then, to collect

not only medical supplies but as much knowledge as possible. One way is through books. Another way, such as my wife is doing, is to work for a doctor for a while. She is presently a dental assistant; and while she cannot perform surgery or other difficult operations yet, she does know all of the basics which most people are ignorant of. Say you have a toothache that is driving you insane. Sure you could yank it out yourself, but would you risk complications such as a horrible infection or disease if there was someone around who knew how to treat such things?

You should also get a few uniforms such as nurses outfits and smocks. They will be great for effect; as Twentieth Century Man will be very uneasy in his new environment. The presence of a mere uniform will put him at ease, and if you are in competition with another quack, this article would easily compell someone to come to you.

Basic medicine is not difficult to learn, either. I once helped run a tourist trap in New Mexico and had to personally give rabies shots to the guard dogs. I had a Veterinarian explain the procedure of mixing the serum and how to give the injection and found it to be quite simple. There was a small community of Chicanos living with us, so I went back to the Vet and wound up giving shots to all of their dogs, too. I got to play "Daktari" for a day and it was fun. But more important, the

people acted as though I had performed some great feat. This is not surprising, because it seems that doctors in general are held in reverence. True, they have the knowledge to heal people, yet many of them are butchers. The rate of alcoholism and drug addiction among doctors is very high, and many of them would do humanity a great service if they found some other work. So I can see no harm in an average, intelligent person setting up his own "practice."

A doctor with limited experience is better than no doctor at all, especially with the uncertain life in front of us. A license will not be required, and anyone entering the field should have no problem in comfortably surviving the difficult times ahead. Perhaps then the word "quack" will have a new meaning.

MAKE MAGGOT SECRETION TO HEAL WOUNDS

THE work of maggots in healing wounds and combating gangrene is being taken over by synthetic chemistry. The tissue-forming substance, allantoin, which is excreted by maggots, has been produced artificially, and is being used to treat various wounds, ulcers, and gangrene. In wars of the past, army surgeons have noticed that wounds infested with maggots, the larvae of the blowfly, healed most prompt-

ly, with fewest complications and least pus formation. In 1929, a surgeon developed a method of treating wounds by introducing live maggots, but there were many disadvantages to the use of living larvae. The new preparation is expected to give the same results without the discomforts and disadvantages.

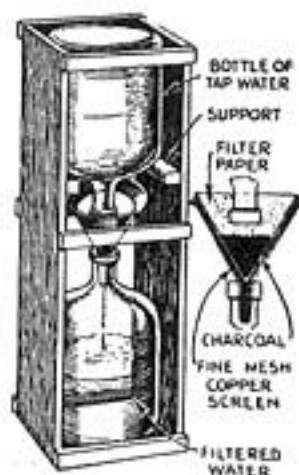
WATER, to Purify.—Put into it powdered charcoal, then filter through a compressed sponge, and it will become perfectly sweet, however impure previously.

Water may be filtered and purified by means of a deep flowerpot, with a compressed sponge in the hole at the bottom. Put over the sponge an inch thick of pebbles, next an inch of coarse sand, next a layer of charcoal, and over again pebbles. The water will filter pure and clear through the hole into another vessel.

An Inexpensive Water Filter

Popular Mechanics 1923

Water can be purified and made palatable for drinking by means of a simple filtering device consisting of two large glass bottles of equal size, some filtering paper, a glass funnel and some powdered charcoal. The rack for supporting the bottles, one above the other, may be made of box wood in the manner indicated. Arrange the cleats that support the upper bottle so that the opening is well down in the funnel. In this way, the flow of water from the upper bottle will be regulated by the height of the water in the funnel and the apparatus will require no attention after starting. The filter is started by placing the empty bottle in the bottom of the rack with the funnel in place. Inside the funnel, place a piece of filter paper, which has been formed into a cone, and put in two or three tablespoonfuls of charcoal, first placing a disk of copper mesh inside



the paper cone to hold the charcoal. Then fill the upper bottle with water to be filtered, cork and place it in the rack. Remove the cork and quickly insert the neck of the bottle in the funnel. About two hours are required to filter a gallon of water.

Nutrition remains a problem

“Nutritional surveys reported in the U.S. and Canada within the last five years have demonstrated an embarrassing number of people on both countries with measurable malnutrition of one kind or another. . .

— Dr. Virgil Wodicka

By RANDY HAMMER

Gannett News Service

Something's wrong with Americans. We talk about nutrition, we read about nutrition, and we study about nutrition.

Yet, more than one-third of this nation's people suffer malnutrition in the form of obesity. And another 5 to 10 per cent are victims of undernutrition.

Malnutrition? Undernutrition? A problem of developing nations, not the good ole USA, the world's wealthiest nation.

Unfortunately, malnutrition is a problem — our problem: “Nutritional surveys reported in both the U.S. and Canada within the last five years have demonstrated an embarrassing number of people in both countries with measurable malnutrition of one kind or another, particularly relating to certain vitamins and minerals. I say embarrassing because we have the knowledge and other kinds of resources necessary to prevent this kind of disorder, and yet even a conservative estimate of the number of cases in the United States would get into the millions,” said Dr. Virgil Wodicka, director of the Food and Drug Administration's Bureau of Foods.

Conservative estimates report 25 per cent of U.S. households do not have nutritionally adequate diets. Other major nutritional surveys repeatedly reveal that from 20-50 per cent of Americans are deficient in one or more of the essential micronutrients.

The most common are deficiencies of vitamins A, B1, B2, C, folic acid, iron and calcium — especially in children and older people.

What does this mean? Well, a deficiency of vitamin B12 can cause poor growth, major anemias, spinal cord degeneration, nervous symptoms, inflamed tongue, gastrointestinal tract disorders, and disturbed metabolism of starches and sugars. All this, according to doctors and the Vitamin Information Bureau, can be caused by a deficiency of just one vitamin.

Let's take vitamin A. Deficiency of this vitamin can cause night blindness, eye dryness and degeneration, dry, coarse skin, mucous membrane impairment (inviting infection) and faulty tooth development.

A deficiency of vitamin B1 can cause retarded growth, depression, irritability and memory loss. A lack of vitamin C can cause bleeding gums, a tendency to bruise easily and weakness. The list of ailments and impairments goes on and on.

The Vitamin Information Bureau attributes much of this public health problem to a trend away from “three square meals” and towards pre-packaged and fast foods.

Following is a list of the major vitamins, their functions and natural food sources:

Vitamin A — Essential to the development and maintenance of skin, teeth, hair, eyes, gums and various glands. Also involved in fat metabolism. Food sources are whole milk, butter, fortified margarine, eggs, leafy green vegetables and yellow vegetables, fruits and liver.

Vitamin B1 — Helps liberate energy from food by promoting proper use of sugars. Necessary for proper function

of heart and nervous system. Food sources are whole grain or enriched bread and cereals, yeast, liver, pork, fish, lean meat, poultry, milk and legumes.

Vitamin B2 — Facilitates the body's use of carbohydrates, proteins and fats, particularly to release energy to cells. Essential to tissue integrity. Food sources are milk, whole-grain or enriched bread and cereals, liver, lean meat, eggs and leafy green vegetables.

Vitamin B6 — Many important roles in metabolism, in synthesis of proteins, in use of fats and in formation of red blood cells. Food sources are lean meats, leafy green vegetables, whole grain cereals, dried yeast and bananas.

Vitamin B12 — Helps build vital genetic substances (nucleic acids) for cell nucleus, and to form red blood cells. Aids functioning of nervous system. Food sources are liver, kidney, fish, milk, and foods of animal origin in general.

Vitamin C — Helps keep bone, teeth

and blood vessels healthy. Important in formation of collagen, a protein that helps support body structures. Main food source is citrus fruits. Other fruits, tomatoes, leafy green vegetables and potatoes are also a source.

Vitamin D — For strong teeth and bones. Helps body use calcium and phosphorus properly. Food sources are vitamin D fortified milk, cod liver oil, egg yolk, tuna and salmon.

Vitamin E — Helps formation and functioning of red blood cells, muscle and other tissues. Protects essential fatty acids. Food sources are vegetable oils, whole-grain cereals, wheat germ and lettuce.

Vitamin K — Required for normal blood clotting. Food sources are leafy green vegetables.

Folic Acid — Assists in formation of proteins and genetic materials for the cell nucleus. Helps maintain functions

of intestinal tract and prevent certain forms of anemia. Food sources are leafy green vegetables, yellow fruits and vegetables, yeast and meats.

Pantothenic — A key substance in body's use of carbohydrates, fats and proteins. Also required for formation of certain hormones and nerve-regulating substances. Food sources are eggs, leafy green vegetables, nuts, liver, kidneys. (Most foods).

Niacin — Present in all body tissues, involved in energy-producing reactions in cells. Aids nervous systems. Food sources are eggs, meat, liver, whole-grain or enriched breads and cereals.

Biotin — Involved in synthesis of fatty acids and production of energy from glucose. Essential to many body chemical systems. A sufficient food source is produced in the body. Additional sources include liver, kidney, eggs, milk, leafy green vegetables and peanuts.

LOOKING OUT FOR YOUR SIGHT

By George W. Preuss

Good eye care habits today may be a major factor in avoiding "post-crash" eye miseries later on. After years of abuse, we're dismayed when they function improperly.

DIET AND DISEASE

The eye's health is dependent upon the individual's health. Upon arising have some distilled water. This helps the body to avoid dehydration and flushes out accumulated body wastes that would otherwise be trapped. By drinking several glasses of distilled water during the day your glands, kidneys, and eyes don't have to compete against each other for moisture. Irregularity and high urine concentrations accelerate the aging process.

To maintain and repair delicate eye tissue, a well-balanced diet is essential. Protein quality is as important as protein quantity, otherwise vital amino acids are overlooked. Fish, eggs, whole grains, milk, all have their place. Fresh fruits and vegetables provide trace elements and minerals that no magic tablet from some laboratory can begin to synthesize in the proper combinations.

Low blood sugar can contribute to eye diseases indirectly. The individual skips balanced meals, feels fatigued later on, and indiscriminately feasts on "junk-food". If you're late for work, (coffee for breakfast) it's easy to over-eat at lunchtime during their "pizza-buffet-special". Not surprisingly, you feel an uplift at first, followed 45

minutes later by "fatigue". Not only is the body strained by the refined sugar, salt and white flour, but the sheer volume of food to be digested taxes the heart, digestive organs and body strength. Pathologists who have done autopsies on heart-related deaths often had patients who exhibited "blood sludge" symptoms in their eyes, years before. Interfered eye circulation was highest among those who skipped breakfast, ate little lunches and then had huge dinners. (One mealers). Those who enjoyed the best health, never over-ate at any one meal, had several meals daily (4 or 5) and nibbled between meals on beneficial foods like sunflower seeds instead of candy.

I urge you to read:

Dr. Josef P. Hrachovec's, **KEEPING YOUNG & LIVING LONGER**, (Los Angeles, California, 90035: Sherbourne Press, Inc., 1972; 1640 So. La Cienega Blvd.) pages 43-124.

If food is tainted, those who over-eat are more likely to get a fatal dose. Even innocent foods, like grapefruit juice, when consumed in excessive amounts, may upset the blood Ph or the sodium-potassium balance and irritate the eye. Unless I had a large family, I'd be wary of those 32-ounce large-size cans of grapefruit juice if I had no cool, glass container to store the contents. The temptation is to drink several glasses in less than 24 hours. Grapefruit juice should be sipped and neutralized by the mouth's saliva and enzymes. Unless the survivor plans very carefully his (or

her) purchases of commercially packaged stored foods, the eyes will suffer from a high carbohydrate, low protein diet. Excessively salty foods dehydrate the body.

A myriad of eye conditions come from Vitamin-A depletion. Snow, sunny beaches, or hours of reading all take their toll. That dry-itchy, sandy-uncomfortable feeling is a warning. Adequate moisture is essential in homes when the forced-hot-air furnace is going. (Put out pans of water.) Another offender is the auto heater, which sends blasts of super-heated dry air at eye level. Take water with you whenever you travel. Natural Vitamin A is preferable to the synthetic. McKesson's Mint Flavored Cod Liver Oil has a tolerable taste. One teaspoon half an hour before a meal provides 78.2% of the U.S. Recommended Daily Allowance of Vitamin A and 97.7% of the Vitamin D. Small amounts taken daily are better than large doses which may be difficult for the body to digest. With the prospect of inflation, nuclear war or more off-shore oil spills, I expect cod to be unobtainable in 20 years. When unopened it has a limited shelf life; read the expiration date. Once opened, store in the refrigerator.

Before you say how terrible cod tastes, think about all the eye irritants like gasoline, pollen, dust, insecticides that you are exposed to daily. Before you rip out your roses thinking that you have rose fever, mow and clear all the weeds growing by your windows. Industry and government won't tell you about the microwave dangers, yet we're exposed from ovens, TV

transmissions, long distance phone systems, radar installations and from TV sets. Is it so surprising that cataracts are more common now among younger people? The eyes are subjected to physical dangers, chemicals, heat (dehydration), excessive light (depletion), radiation and man-made technology. The eyes need both rest, and at least half an hour of natural light each day. Yet we often work in office buildings, under fluorescent or incandescent light, sit for hours and then walk out into the night pollution. Ideally we should get up, move around for a few minutes each hour to help the circulation.

Daily, steady exercise like walking assists digestion and aids the eyes get rid of wastes. There may be value in resting with our feet higher than our head. Gently placing the palms against the closed eyes gives them comfort. Don't press them.

Avoid soaps that irritate the eyes. Room-temperature distilled water next to closed eyes may stimulate circulation. Improving the circulation to the extremities helps the eyes. Rubbing the feet (every other day most effective) firmly with the hands can begin a toxin-flush that will improve circulation. If you wake up feeling exhausted or your mind wanders while working, are you getting enough fresh air?

After cataracts, glaucoma is a major cause of blindness, through the loss of peripheral vision. Although the exact causes are not known, some tentative

observations are worth mentioning. Avoid smoking, tension, and have regular ophthalmological pressure-examinations. It tends to be hereditary and is often accompanied by diabetes. One should drink small amounts of water throughout the day, rather than raise the osmotic pressure by drinking a massive volume at one sitting. One theory holds that drinking water impurities over the years is responsible for excessive eye pressure. It would be prudent to drink distilled water and get enough Vitamin C, a detoxifier. Stockpile and rotate prescription eye drops.

To prevent injury or accidental loss of sight, everyone should own a pair of safety glasses. After several accidents with supposed "safety glass lenses" where they shattered into tiny fragments, I'd be wary of glass altogether. If you are myopic or have thick lenses, instead of going the contact lenses route, consider plastic lenses. Although they scratch easily and are ruined by silicon cleaners, they will take tremendous impacts or falls and not fly apart. The lenses will "pop out" and can be returned to your frames.

In a low-inflation economy where fashion is important, plastic frames are o.k., but if you want something that will field strip easily for repairs and cleaning, buy metal frames. Get frames that have hinge screws for the earpieces, screws that hold the lenses, and screws for the adjustable nose pieces. (6 screws in all). Get extra

screws and don't assume they are interchangeable. With metal frames, all you need are an extra pair of plastic lenses, a set of jeweler's screwdrivers, screws, some Glaz-cote for cleaning, extra plastic earpieces, and you'll have a pair of lifetime glasses.

If you notice "waves" or spiderwebs around auto headlights, that may indicate glaucoma, or if after an eye injury a possible corneal abrasion. Before you have the surgeon scrape the cornea to the basement layer, there are several things you can do for that abrasion.

I'd be extremely careful with steroid-based eye drops and use them exactly as the doctor prescribes. Otherwise you can scar the cornea and you'll have bothersome "dark spots" that move across your field of vision. Another serious mistake that corneal-abrasion victims make is to read, get into brilliant sunlight or even use their eyes when one eye is patched. This puts terrible strain on the uninjured eye and encourages the eyes not to work together. If one eye is in brilliant sunlight and the other is in patched darkness, this creates dilation problems. Resting both eyes is essential. After the patch is removed there may be difficulty, for awhile, in getting the eyes to work together again. To regenerate damaged corneal tissue, proper diet with cod liver oil can be the determining factor in a swift recovery or a lifelong affliction. □

SURVIVAL DENTISTRY

By Steven Rosen, D.D.S.

(Editor's Note: 19th Century technology may really take care of your most immediate needs after the crash but this does not apply to dentistry. Nothing but horror tales come down to us about the suffering attendant to old-fashioned dentistry. Most people preferred to let their teeth rot out rather than visit "Painless Pierre."

Laughing gas (nitrous oxide) was the most common; and not too effective painkiller used by dentists then.

After the crash it will be some time before you can expect to visit a dentist with X-rays, novacaine, highly specialized electronic drills and other dental equipment which makes modern dentistry relatively painless, safe, effective in preserving the ailing tooth or teeth and lasting in its application.

Rather than facing having ailing teeth yanked out for good by a friend with a

rusty pair of pliers, you'd do well to get all the tooth care, repair, dentures, and anything else you might need which will set you up teethwise for the next few years.

Even now, I'm in the process of having my teeth thoroughly gone over; first cleaned, then X-rayed, then all the cavities drilled and filled. I advise you to do the same after you've read Dr. Rosen's article.)

The last subject you would probably consider in making preparations for any survival attempt is your teeth. A little precaution now, however, may save you from much misery in the future. Remember, unlike the physician, it is difficult for the dentist to perform without electric power and a reasonable variety of instruments and equipment.

The first matter to consider is the

present condition of your mouth. Notice that I said mouth, not just teeth. Be sure that your teeth are free of decay and gum disease. Any treatment that is advised should be accomplished. If no mention is made as the condition of your gums, be sure to ask. More teeth are sacrificed to gum disease than to decay. See a specialist if you can get no firm answer from your present dentist. I cannot overemphasize this point. Once your teeth and gums are well restored, it is really a simple matter to learn the proper methods for maintaining good oral health. An added benefit of maintaining good oral health is that various stress-related problems can be avoided altogether. Trench mouth, appropriately named by foot-soldiers, is a prime example. The exact cause is unknown, but stress is usually always associated with its appearance on the scene. Good oral hygiene will usually prevent it from ever happening. Believe me when I say it is a common occurrence. I see it often among those undergoing divorce proceedings, college students

cramming for exams, and executives in the high blood pressure category.

Next, be sure you receive a complete set of X-rays. This should include 14 to 16 X-rays made with the film placed inside the mouth. If only two or four X-rays of this type are made, chances are the dentist only checked for cavities. The added X-rays are to check the root and the bone surrounding the teeth. Many problems, such as cysts and cancers, to mention a few, can be found. These problems would remain hidden without such an examination until they became more serious. If possible, get a panoramic X-ray made also. This is relatively new. You sit in a chair, or stand depending on the brand of machine used, and the X-ray film and X-ray beam actually revolve around your head. This type of X-ray shows both jaws from ear to ear, and part of the sinuses. Again, books have been written on the problems this type of X-ray can reveal. Both the complete series of X-rays with the film placed in the mouth and the panoramic X-ray are usually made every three to five years.

Last, on the subject of a good examination of the mouth, is a check of the soft tissues, i. e. the cheeks, tongue, roof of the mouth, floor of the mouth, salivary glands, and lymph nodes of the neck. (When your doctor says that you have "swollen glands" and he or she is feeling your neck near the jawbone, the structure is really a lymph node.) This type of examination is designed to screen for cancer, but many other problems, such as tuberculosis, syphilis, vitamin deficiency and many other problems too numerous to list are often found this way. Did you know that about 6% of all cancer occurs in the mouth? You may have to find someone who graduated from dental school within the past ten years to perform this type of check-up, as I don't believe older dentists were acquainted with these techniques while in school.

Should you be forming a survival group and have a dentist as a member, you can do what other contributors and Mr. Saxon advise. Stockpile. Your dentist will know what is needed and how to properly store the materials. Believe me, you will not appreciate the dentist until his or her services are really needed.

Ultimately, from a dental standpoint, survival means prevention. You need to learn the proper use of and selection of the toothbrush, dental floss, and plaque revealing agents. If you have followed what I have suggested, and have reached the stage where no gum disease, decay or related problems exist, and all X-rays are negative, then the responsibility is yours alone.

Next, here are some suggestions for

evaluating dental care. I believe the need for this type of information is long overdue. Before beginning, let me state that what follows is strictly my own opinion. Also, by no means is my list complete.

First, here are some warning signs to look for should anyone recommend a dentist. You can also use them to check on your present dental care. They are:

1. Complaints of pain or irritation lasting even for weeks after a treatment. Prolonged sensitivity to hot or cold foods which doesn't go away after the food is swallowed, but may last for minutes, is a good example.

2. Continual (day after day) bleeding of the gum around a cap, bridge-work, or a filling when using a toothbrush or dental floss. Either these restorations were made incorrectly, or they have outlived their usefulness and need replacing. If you find bleeding around all of your teeth when you brush, you probably have gum disease and need to have this attended to.

3. "Catching" or tearing of dental floss when cleaning around a cap, bridgework, or a filling. This usually will happen at the edge of the cap, bridgework, or filling which is usually below the gum line. Normally, these areas should feel smooth when flossing.

4. Pain or other problems when biting or chewing after any dental treatment, even after denture are made. These problems should last no longer than three or four days. Dentures may require several adjustments by the dentist to relieve any pain or discomfort.

5. Caps or bridgework on the front teeth which you can spot right away. You know they are not the real teeth. Normally, you should not be able to tell the difference.

6. When dental floss is passed between two teeth where at least one of these teeth has a cap or filling, the floss should not simply slip through. The floss should meet some resistance. Teeth are supposed to touch each other so that food doesn't pack in between them. This can lead to both gum disease and tooth decay.

7. Dentures or partial dentures (those with metal frameworks) completed in only two appointments. Quality dentures demand that the patient be seen more than two times by the dentist.

8. Were new dentures or partial dentures simply handed to the patient? Normally, the dentist should examine them in the mouth to see if any adjustments are needed at the time. Did the dentist schedule another appointment, at no extra cost, for a check to see if adjustments are needed after the dentures are allowed to "settle" in the

mouth? This adjustment is usually made after the dentures have been used for about a week.

9. Was an immediate denture (where all teeth are removed and a denture placed in the mouth at the same appointment) made to replace the lower teeth? (This procedure is acceptable for the upper teeth only!)

10. Do the dentures give an individual "perfect" teeth? Dentures can be made to account for age, hair color, and face type. You should not know someone is wearing dentures if they are well made.

11. Can the denture wearer comfortably bring his lips together and swallow? If not, several problems can develop. Properly made dentures take these and many other factors, such as speaking, into consideration.

12. Was instruction given for the proper cleaning of dental restorations? Without proper cleaning, no dental restoration will last very long no matter how well made! In a clean mouth, even the worst dental restoration may last a very long time. Did the dentist give warnings as to what new dental restorations such as bridgework and dentures cannot do? For example, no matter what anyone tells you, you should not bite through apples if you wear dentures!

13. Does the dentist stress prevention? That is, was instruction offered in the selection and use of the toothbrush, dental floss, and plaque revealing agents? Did the dentist or his or her assistant tell you about plaque (pronounced "plak," with the "a" as in "back")?

14. If a "root canal" was performed (needed when the "nerve" of the tooth is permanently damaged), was the patient told that the tooth is more likely to fracture now? Was the proper follow-up treatment, which included a metal post placed inside the tooth followed by a crown, offered? The post should prevent fracture just like the steel reinforcing bars in reinforced concrete prevent fracture.

15. Was a lead apron used to protect the patient from stray X-rays?

16. Was a complete set of X-rays made? A minimum of 16 X-rays with the film placed inside the mouth should have been made.

17. Have there been problems with receiving attention in an emergency?

18. Does the dentist appear to avoid reasonable complaints?

19. Did the dentist tell you of the health of your gums and the bone which supports the teeth? Ask if the dentist used a "periodontal probe" in making this determination. This is the best instrument for checking the gums and bone. It is even better than X-rays.

20. Did the dentist tell you the plan of treatment he or she has decided is best for you? This should be done before any treatment is started.

The next suggestion is to call the local dental society. Dentists establishing new practices often ask these agencies for referrals. Since they are seeking new patients, these dentists may give more personal attention than someone you might have to wait three months to see.

If you are planning to move, your present dentist may offer the names of several dentists for you to consider.

One last thought, if all of the above should fail:

1. Call a dentist located near your home.

2. Explain to the receptionist that you are seeking care, but the idea of a new dentist frightens you. Ask to speak with the dentist, saying that this would make you feel more comfortable. If the dentist is busy, see if your call might be returned.

Don't let yourself be talked into visiting the office first. The idea is to see if the dentist cares enough to make him or herself available to patients when personal attention is really needed.

3. If you are still unsure after all of this, ask if you can visit with the dentist's office to talk with some of the patients. See how they feel. Use several of the warning signs I have suggested when you talk to these people.

In summary, no set of rules or guidelines are perfect. I can only hope that what I have presented gives you something a little more solid to work with.

One last thought concerns toothpaste. You should stockpile a good fluoridated toothpaste. While many water supplies are presently fluoridated, who knows where your water may come from in the future. Stay away, however, from any toothpastes listing Stannous Fluoride as an ingredient. What the manufacturer

fails to tell you is that with time, the fluoride reacts with calcium in the other components of the toothpaste. While it has not as yet been proven that this decreases the effectiveness of the fluoride, why take a chance. There are many other products to select from.

Should there be sufficient interest, I will offer future discussions on topics such as: other stress related oral diseases; proper selection and use of the toothbrush, dental floss, and plaque revealing agents; emergency denture repairs; other forms of emergency care; or whatever anyone would like to have discussed.

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Register-Republic, Rockford, Wed., March 1, 1978

Is there a criminal mind?

**Jim
Bishop**



Is there such a thing as the criminal mind? Science has studied the question for centuries. Science seldom agreed with itself. Ten years ago, sociologists concluded that criminals are victims of society.

Their contention was that drug abuse, alcohol, child abuse, poverty, and deprivation combined in varying degrees to produce the criminal. Now we have a study in two volumes that maintains there is such a thing as a criminal mentality, and that he shares certain easily-spotted characteristics which identify him.

The work is called "The Criminal Personality." For 16 years, Dr. Samuel Yochelson worked in St. Elizabeth Hospital in Washington, D.C., with criminals. Some years ago he was joined in this study by Dr. Stanton Samenow. Together they observed over 200 outlaws, got their life stories, interviewed wives, parents, siblings, schoolteachers.

THE HARDER THEY labored to find a way of reforming the convict, the more it eluded them. Many who had gulled juries to believe that they were insane tried hard to convince the doctors that they were presently sane and

responsible citizens. And should be freed.

Yochelson and Samenow started out with the noble notion of trying to prove that malefactors could be refashioned into good family men. Their conclusions are the opposite.

The true criminal is, first of all, a consummate liar. Often he will lie without motive, merely to keep in practice. He is dominated by a frenzy of fears, much of it dating to infancy. Although these frights are multitudinous, the major ones are fear of death, injury and rejection.

It does not matter whether the criminal is brought up in a ghetto or a mansion, the characteristics are common to all. The criminal displays enormous control of his fears and, when he is ready to commit a crime, buries all of them under an avalanche of optimism. The crime will work. He will get rich. He will get away safely. Immediately after the crime, all the fears return.

He cannot endure a put-down. He refuses to be rejected by society, friends and women. His constant state is anger. Samenow writes: "Anger is as basic to his personality as the iris is to the eye." In his waking hours, he is literally mad at the world.

His forays against law prove to himself that he is smart. He feels a sense of danger and of pride in executing criminal acts. It makes him a man in his own eyes to feel contempt for society and law.

Michael Serrill of Psychology Today conducted an interview with Samenow,

who cannot excuse the criminal mind.

"They were in contact with reality," he said. "They were in control of their behavior." And yet almost all of the convicts in the group had been found not guilty "by reason of insanity."

Very early in life the criminal rejects responsibility and work. He will not attend school, obey his parents, or keep a job. What he seeks is excitement. He finds it in wrong-doing. When cornered, he lies and swears he will mend his ways.

The importance of this study is that it runs counter to a body of scientific thought which has been telling us the criminal has been victimized by society. Samenow believes it is possible to reform a few criminals by holding an accurate mirror before their eyes. Let them see themselves as the fearful cheats they are.

A FOG OF DOUBT is in my mind. Anyone who commits three felonies is an incurable recidivist. He should be put away forever — no parole. Crime is expensive. Taxpayers support 283,000 convicts in federal and state prisons.

Add to that the cost of local police departments, county sheriffs' departments, state police and private security guards. Add to that the cost of all the criminal courts and you find that the cost of keeping your life and property is expensive.

WATER, to Purify.—A large spoonful of pulverised alum sprinkled into a hoghead of water (the water stirred round at the time) will after the lapse of a few hours, so purify it, that it will be found to possess nearly the freshness and clearness of finest spring water. A pailful containing 4 gallons may be purified by a single spoonful; or a mixture of one part chalk and two of alum will be still better.



Training With Cables

by Mike Brown

Cont. from Vol. 1, page 135

The original "cable set" was a bow. Archers trained by using progressively heavier and harder to bend wood. Even though the bow was a great technological improvement over the stone, the club, the sword, and the spear for long-distance organized mayhem the fact remained that a strong arm launching the arrow was still a decided advantage over a weaker one.

Magellan's men captured a couple of South American natives in the 16th century. The natives' favorite exercise was pressing against a bow with their feet and pulling the bowstrings with their hands. Sort of an economical and simplified version of the "rowing machine." You can rig one up with the leaf spring of an automobile and some surgical rubber.

The type of strength developed with cables is basically the type prizefighters and some wrestlers develop -- not much for moving inanimate objects but hell on other people. Cables act like an opposing human muscle, and one of the best cable exercises is to hook your set onto the wall and "wrist-wrestle" yourself.

For looks, for shape, for "pump", and for arm and shoulder development cables are hard to beat. Unfortunately, for the legs and lower back they are almost useless.

The primary thing to remember when working with cables is that they are not a barbell set and the same "rules" do not apply. This may appear to be a silly statement until you realize that while certain barbell and dumbbell "movements" (e.g., upright rows, curls, one-arm press, triceps extensions, etc.) can be duplicated in form they are not the same exercises, the muscles are not affected the same way, and your cardio-vascular reactions will be entirely different.

The first basic difference is gravity. No matter which way you lift a barbell or dumbbell the resistance is always towards the ground -- gravity. This is not completely true of pulley machines hence their great popularity with contest

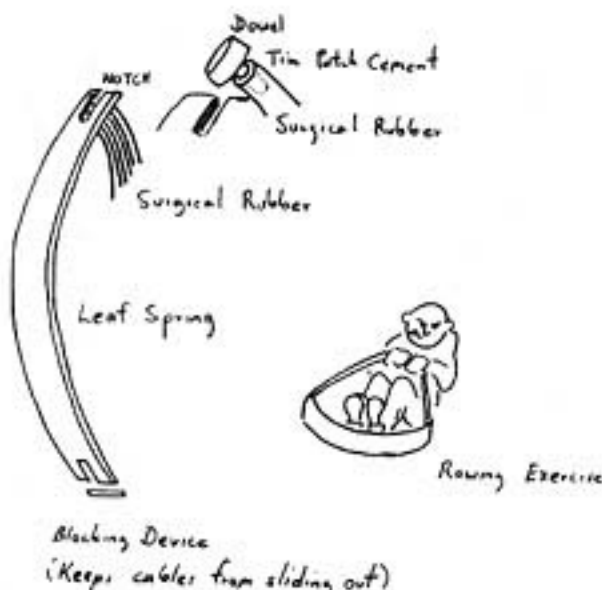
development of a "natural" strength curve. Which means the muscles would look more natural -- and better looking -- than those developed solely by barbell training. Gymnasts quite often develop such natural looking muscle, even though they are basically working against gravity. The trained eye can easily discern the difference between the physique of a gymnast and (some) bodybuilders.

The third basic difference is that -- because of the effects of gravity already mentioned -- the muscles are affected from angles the barbells and dumbbells are incapable of duplicating. One of the most striking examples of this is found in Iron Man magazine Vol. 24 No. 3 on page 30. A young lady used two cable exercise with some light dumbbells and a barbell for a year.

The cable exercises were for her bust. Her starting measurements were 35½" bust, 26" waist, 37" hips. I've never even heard of a woman "shaping up" like that with weights alone.

The fourth basic difference is that an isolated muscle under optimal conditions will work at 20 to 25% efficiency. It is far easier to completely isolate a muscle with cables for the simple reason that the rest of the body is not called upon to support any weight. In other words, energy expenditure by the rest of the body is eliminated -- such as a fellow doing standing barbell curls whose back and legs must support the weight the biceps are heaving around.

The fifth basic difference is that cables can be moved much faster than a barbell. Which means that the muscles worked can put out the same amount of "steam" as they can with a weight, only in less than half the time. Which in turn means that the heart and lungs are put under greater stress to pump blood and oxygen to the muscles -- in simple everyday English, either start off slowly or you are liable to find yourself barfing all over the place.



winners and some athletes. With a cable set the resistance can be at any angle with a flip of the wrist -- and the resistance is the center of the cable set itself. To use a ridiculous example, you could build muscle with a cable set on a space ship (with no gravity) whereas weights would be useless.

The second basic difference is that the resistance of a cable increases (it progressively requires more expenditure of strength and energy) the farther the cables are pulled apart. The farther the cables are stretched, the more the muscles involved must contract. Supposedly the more a muscle contracts the more power it is capable of (due to skeletal leverage, inserts, tendons, etc.) and a cable set would then appear to assist more in the

A COMPLETE CABLE ROUTINE

by Mike Brown

What follows is not actually a complete cable routine; it is more like the working material to build two complete cable routines with some other exercises thrown in for all-around conditioning. The exercises are given in the order that they should be performed. Instead of suffering through a dozen exercises, simply choose six of them for use during the first six weeks to three months and then use the other six during the second period. Changing routines will keep you from becoming stale -- that is, so bored you can't do the exercises properly or with any amount of drive.

SKIP ROPE: Try to get one of the skip ropes of the type used by prizefighters -- with a thin leather rope and ball-bearing wooden handles. An old clothesline rope

simply doesn't get it for two reasons. First, it is so thick that the air slows it down. Second, the angle the wrists are held at in rope skipping fouls up any ability to keep the rope turning fast enough. You should be trying to work your legs and lungs; any mechanical inconvenience simply hinders your ability to work out properly. In the case of a skip rope harder is not better; faster is.

Do not skip rope on concrete. It's like gently tapping your spine and the arches of your feet with a sledgehammer. You won't notice the ill effects at first because they are cumulative. Try to use a wooden floor. A wooden floor will give, even though imperceptibly and save your back and feet from shock. In addition you'll be able to tell how smooth your movements are becoming. When you start off, the whole house will probably shake. As you become more coordinated you will feel much lighter on your feet. Eventually you will not be able to hear your own feet hitting the floor. Then you have arrived.

Alternate your feet—two strokes on one foot and then two strokes on the other—the way prizefighters do. You get maximum speed that way. Forget all the little girl stuff.

Work up to fifteen minutes before every workout. You probably won't be able to last more than a couple of minutes at first and—if you're like most people—it will take you at least a month to learn to do it properly. Keep at it. It's worth it. When you get to where you can skip at full speed for fifteen minutes you'll begin to experience a high that is simply unbelievable. It comes from improved circulation and oxygen rushing to the brain.

It is important to be worked up before you start. Prizefighters are not taught technique until they are exhausted, for two good reasons—a man who is pooped will not tense up and get himself hurt and has a tendency to do exactly as he's told and consequently learns much quicker since failing to follow directions is the quickest way to wind up doing more work. We hope the same will apply to you when



One-Arm Press



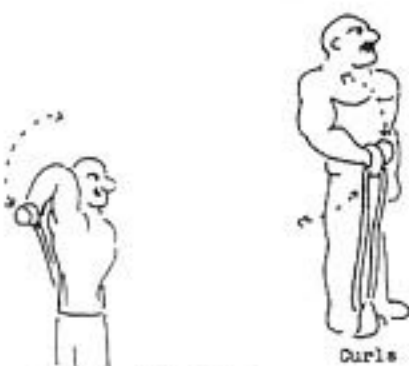
Hyperextensions



Pushups



Towel Leg Curls



Triceps Extension



Curls



Neck Work



Pectoral Exercise

you start your cable routine.

ROWING EXERCISE: Illustrated in the last issue. Two sets, twenty repetitions. Alternate with chin-ups every six weeks to three months if you have a chinning bar. When you do chins, face the palms toward you (the old barnyard chin) but make sure the little fingers are within a couple of inches of each other—you get maximum stretch that way

and more muscle area is worked.

In the following exercises which are illustrated and hopefully long how-to-do-it instructions are not necessary be very careful in one regard: always make sure that for any muscle exercised the antagonistic muscle is worked. In other words, if you select a bicep exercise make sure you counter it with a tricep (the muscle on the back of the upper arm) exercise. If you don't you're liable to wind up with one muscle so much stronger than the other that when any stress is put on the weaker muscle by the stronger the weaker one simply rips right up the middle. I had this happen once last year when I was doing squats—I got to where I was doing fifteen repetitions in the deep-knee bend with 275 lbs. on my back. I was doing nothing for the back of my legs—the thigh bicep. One day I decided to run full bore around the track and made it about 150 yards when it felt like the back of my entire right leg simply unraveled. It was black and blue for weeks and looked like somebody had worked me over with a hot iron.

The illustrations should explain these:

ONE ARM PRESS

UPRIGHT ROWS

CURLS

TRICEP EXTENSIONS

CABLE PECTORAL EXERCISE



Upright Rows

The illustrations should also explain the following but they are done with a towel:

LEG CURLS

NECK WORK

To wind up, do LEG RAISES for the abdomen and HYPEREXTENSIONS for the back. PUSH-UPS with the feet elevated and a friend pressing down on your upper back are a good antagonistic exercise for the cable back and bicep exercises.

Do two sets of twenty of every exercise except the neck work (do ten) and work as FAST as possible. Not only does working faster result in increased cardio-vascular efficiency but the muscles grow faster too.

One final word of caution: when I say FAST I mean don't sit around between exercises—but do the exercises themselves slowly and carefully. In other words, your work should be CONSTANT.

GOING APE

By Mike Brown

So you want to look like Li'l Abner—all arms, chest and shoulders with slim hips, waist, and legs? If you're heavy into swimming, sailing, or cliff scaling such a physique becomes highly functional. Most of the speed generated through the water is done by the hands, a square-rigged sailing vessel requires swinging around like a monkey, and cliff scaling should be self-explanatory.

There are a few basic things to remember. They cannot be over-emphasized.

First, 80% of your progress will take place through nutrition. Exercise tears muscle down; only the RIGHT foods and food combinations can build muscle back up with the little added "extra" for next time that nature normally provides.

Second, the NEXT 15% of your progress will depend on careful and systematic attention to your exercise PROGRAM. Notice I said program, not amount of weight lifted.

Third, only 5% of your overall effort should be directed to increasing the weight on the barbell. That's right, the weight is of minor importance. It is far more important that you do the exercises in STRICT form and do them right.

Let's discuss the above in reverse order of importance.

First, the exercises. They are all fairly basic but nonetheless effective. You'll need a barbell with a 6-foot bar and a hundred lbs. of plates should be sufficient for starters. Try to get a bar with a revolving chrome sleeve and end collars. Altogether you should have about a hundred and twenty five lbs. of liftable iron. Stay away from the sets with plastic coated plates—the plastic tends to separate and the "guts" of the plates fall out. You can get a good used set from the neighbors kid who gave it up, ads in the newspapers, etc. for about ten to fifteen cents a lb. Or barter for one.

All you need at the moment is the barbell. However, you're going to need a set of dumbbells and an exercise bench for the next lesson so diagrams are illustrated for their construction. This program is for six weeks and six weeks ONLY.

The exercises are as illustrated and are to be performed keeping the following in mind:

1. Military Press. Hands shoulder width apart, palms facing outward. Feet and knees together. Back straight—do NOT lean back when doing this exercise. At the finish the weight should be up and BACK—about the level of the ears.

2. Dead Hang Cleans. Hands shoulder width apart, palms facing in at the start of the movement and out at completion. This is not a reverse curl. Dip the knees slightly to get the weight started moving, keep the bar as CLOSE to the body as possible doing the movement (about an inch), and "flip" it with an elbow (not wrist) movement onto the shoulders.

3. Upright Rows. Hands approximately four inches apart, palms facing in. An easy way to get the spacing on this one is to simply curl the thumbs until they touch—that's about four inches. Then curl the thumbs back under the bar when you start the exercise.

Raise the bar to the chin, keeping the elbows high. Let the shoulder muscles do the work. Lower and repeat.

4. Curl. As illustrated. Keep the shoulder blades pressed flat against the wall in order to keep from "swinging" the weight. Palms facing out at the beginning of the movement, in a shoulder level. Hands shoulder width apart. If possible get a bent bar (illustrated) as the true function of the bicep is to rotate the hand, not bend the arm—which is easily seen by keeping the palm pointed toward the ground and then raising the hand.

5. Lying tricep press. Hands four

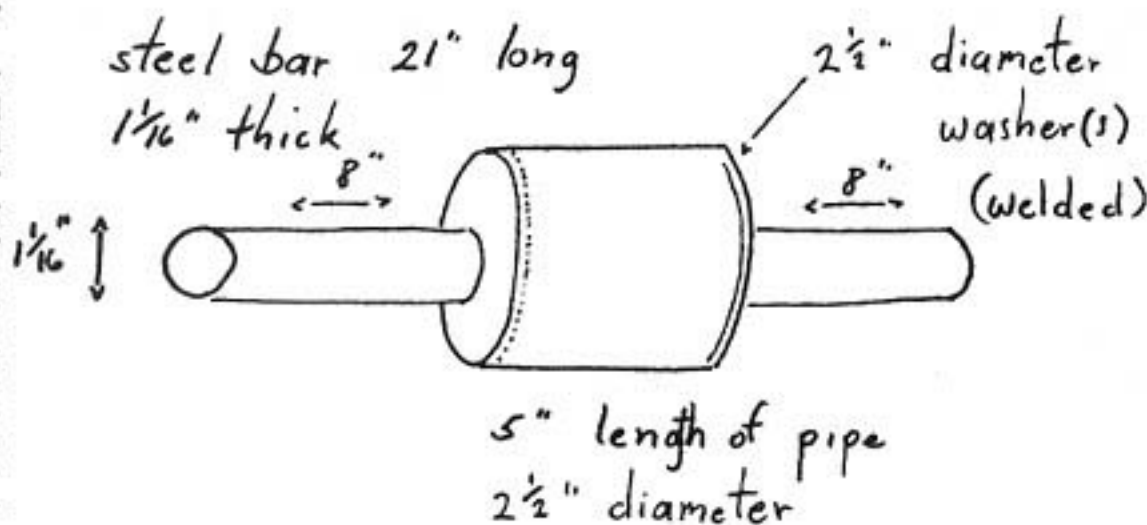
inches apart. KEEP the upper arms perpendicular to the floor. Only the forearms should move. Use forward and reverse grip. Lower to hairline. The tricep is where the bulk of your arm muscle comes from—so this exercise is critical.

6. Front Squats. Grasp the bar with palms facing out, about four inches apart. Stand up. Now curl the bar onto the shoulders. The bar should be resting comfortably on the deltoid (shoulder) muscles and the arms should feel very little pressure.

Keep the feet about six inches apart, toes pointed out. Go into a deep knee bend. On your toes. Take a deep breath BEFORE you start your descent. Exhale on the way up. Try to imagine yourself in water up to your neck and breath EXACTLY the same way as if you were doing your squats in a swimming pool. Keep your back and hips straight. As you grind out the repetitions you should start feeling tremendous pressure on your rib cage and lungs. This is basically a CHEST exercise though it also benefits the legs.

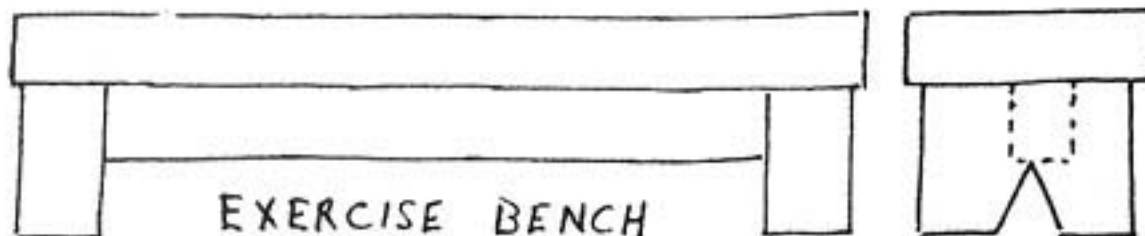
7. Towel Pulls for Thigh Bicep. The exercise should be self-explanatory. Primarily to protect you from injury.

So much for the 5%. Now for the next 15%—the program order.



DUMBBELL

Build two, use standard outside collars



Only two exercises are to be done on Mondays and Thursdays, three on Tuesdays and Fridays, and two on Wednesdays and Saturdays.

Here's the way it looks:

Monday and Thursday

1. Military Press

2. Dead Hang Cleans

Tuesday and Friday

3. Upright Rows

4. Curls

5. Lying Tricep Press

Wednesday and Saturday

6. Front Squats

7. Towel Pulls

There is a reason for this way of doing things so—if you rearrange the schedule to "improve" it and don't get any results—your failure is your own. By working the large muscle groups with heavier weights before each day of arm and shoulder work the blood vessels enlarge, facilitating the carrying of excess nutrients to the muscles, in turn causing extremely rapid muscle growth.

For the first two exercises do three to five sets, ten repetitions each, depending on how you feel that day. You are only allowed FIFTEEN SECONDS between sets. Obviously you are not going to be using a whole lot of weight. The following day you will be using even less.

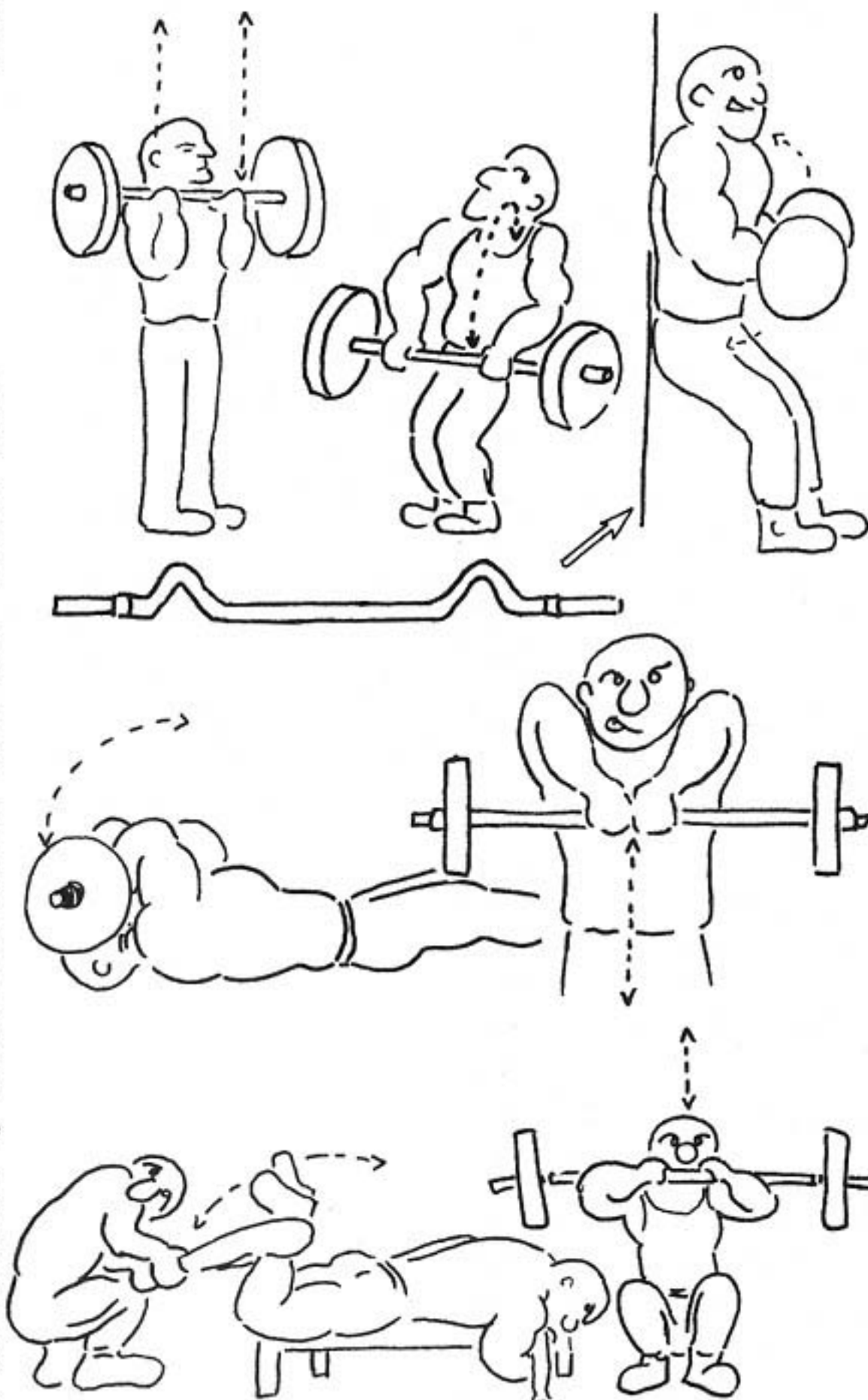
The next three are all arm and shoulder exercises—and the "pump" you get should be unbelievable if the muscles have been "softened up" the day before. One set of each exercise—with AT LEAST twenty repetitions per set. Do them STRICT (no heaving, bending, or cheating) and KEEP GOING until you simply can't move. Once you are EASILY past twenty reps then add NO MORE than 2½ lbs. Remember, increasing the weight is of minimal importance. The main thing is CORRECT FORM.

Training for strength, size and shape will follow.

On the lying tricep press you will have to do two sets—one with forward and one with reverse grip. Always do the one you can handle the most weight in first. Over twenty reps also here. If at the end of the second set of these it feels like your arms are going to fall off, fine—that's the way they're supposed to feel. If you're not hurting, you're not working.

Limit yourself to thirty reps on the front squats and towel pulls—no need to kill yourself on these and squats have a nasty habit of becoming all day affairs: fine if you're in training to run the marathon but unbelievably time-consuming for anyone else.

Keep in mind this in ONLY a six-week routine. Your system won't be able to handle it any longer. Once you're through with it take a week lay-off before you start



the next program.

For your diet get plenty of fresh fruit and vegetables, lean meats, eggs, cheese, and milk: be sure to eat an orange anytime you drink milk. A quart of milk with an orange as a chaser is an excellent bedtime

snack for almost instant overnight bulk. However, there are some better and more sophisticated bulk producers. Stay tuned for NUTRITION SECRETS OF THE SUPERSTARS.

GOING APE

(PART TWO)

by Mike Brown

To achieve really monstrous size and strength there are a few things you need to know that are simply not taught in the average muscle course or book. There's a reason. Generally muscle-building courses are written by contest winners — most of who got that way through years of persistent hit-or-miss efforts and as a result are never completely sure what their progress was attributable to. Better you should ask his coach (if he had one).

An overwhelming number of what appear to be outstanding physical specimens are actually by-products of the drug scene. A class of drugs known as anabolic steroids, sold under such brand names as Dianabol and Anavar, is responsible for much of their muscular size. What such drugs do is force utilization of protein the body would normally reject. It's a good way to destroy your liver. The liver is quite an organ; it can be cut in half and it will grow back to full size, regenerating itself like the tail of a salamander. Which may have something to do with the almost miraculous properties of dessicated liver for physical conditioning but the liver, like the salamander, can be easily poisoned.

Another method popular with the "big boys" is vitamin B12 injections. Contest winners have been known to gain 10 pounds of solid muscle in two weeks. There are a couple of disadvantages here too. The first is that anytime anything is injected into the bloodstream there is almost no way to filter out any impurities. The "swine flu" hoax perpetrated on the taxpayers by Big Brother is one glaring example. The second is that ALL B vitamins are supposed to be balanced against each other — which means if you get an overdose of B12 your system is going to be short of B1 all the way up to B17. And a shortage of B17 causes cancer, regardless of what the A.M.A. and the pharmaceutical companies would have you believe.

There are other methods to cause rapid increase in muscular size. One of the best is to sip water between every set of every exercise. And I mean sip. Take a good healthy swallow every time instead of a dainty sip and not only will you get nauseated a third of the way through your workout but you'll begin to feel like the ballast tank of a submarine in a crash dive. The idea is to ingest just enough water to replace the bodily fluids you lose during a workout — about two to four pounds. Instead of starting a workout

weighing 170, sweating off four pounds to 166, staying dehydrated until supper at 166, shoving four pounds of food and drink into your system at supper to return yourself to 170, drinking a quart of milk and eating an orange at bedtime to get yourself to 172, exhaling and perspiring 1.9 pounds during the night, and winding up with a three or four pound weight gain for a month of hard work, try the water treatment. If you're 5'10" you'll weigh a burly (not fat) 280 in no time. A word of caution. Never drink quantities of water with meals. It washes everything (protein, minerals, vitamins, etc.) right back out. Honey mixed with your workout water will give you more energy.

Now for the routine.

The equipment you need for it is on page 216. The purpose of the thick-handled dumbbells is to develop your grip. The forearm is over 50% tendon and ligament, it simply won't pump up like an upper arm so it must be worked differently. Grip strength can be developed simply by holding on to a heavy object — the thicker the object, the harder the hands and forearm muscles are worked. The idea here is to use the thick handled dumbbells in all your dumbbell exercises. You do not have to do any direct grip exercises whatsoever — just holding onto thick handled dumbbells while you exercise other parts of the

body does the job. Basically, this is how the old-time strongmen developed the finger and hand strength to tear decks of playing cards and telephone books in half, bend horseshoes, spikes, iron bars, and tear silver dollars in half with their fingers. Remember, tendons and ligaments do not extend and contract like a muscle and simply cannot be developed in the same fashion.

This routine is considerably harder than the original "GOING APE", don't try it until you've had six weeks of the first one. If you've successfully completed the first routine take a week or two off and then try this one. Six weeks is also the limit on this one.

Exercises:

1. The bench press. If you can, get someone to hand you the weight. Make sure you have a firm grip on the bar before he moves it over your face in case he slips. Take a deep breath before you lower the weight, hold it (the air), lower the weight to your neck, and exhale on the way up. The bench should be narrower than shoulder width. Keep the elbows pointed out. Four sets of eight repetitions.

2. The chest lateral. Three sets of twelve done in between the bench presses. Lie flat on your back on the bench, grasp the dumbbells with the palms facing each other and arms perpendicular to the ceiling, and lower the arms with palms up until the handles are parallel to the top of the head. Most people lower the weights until the hands are parallel with the chest but they get inferior results that way.

3. Seated press behind neck. Use a wide grip. Five sets of eight.

4. Seated palms front dumbbell press (illustration). Four sets of eight.

5. Seated dumbbell side laterals. Keep the palms down, elbows slightly bent, and index fingers lower than the forefinger, forefinger lower than third, etc. (cocking the hand forward). This is a shoulder (deltoid muscle) exercise if done properly. Three sets of eight.

6. Upright rows. Illustrated on page 216. Only this time use a wide grip (about shoulder width). Three sets of eight.

7. Dead hang cleans. Illustrated and explained on page 216. Four sets of four. Use heavy weight this time.

8. Rowing motion. Bend over at the waist and bring the bar up to the chest, then to the waist, then back down again in a circular rowing motion. Four sets of eight.

9. Deadlifts. Three sets of eight in between the rowing motion. Just bend over and pick the weight up using your legs and back. Do not bend the elbows or use the arms for anything except to hold



onto the weight. When the weight is as high as it will go without bending or using your arms try to touch your ears with your shoulders (shrug) and then roll your shoulders back, lower the weight, and repeat.

10. One arm dumbbell rows. Brace one hand on the bench while you bend over at the waist and bring the dumbbell up to the chest. Lower and repeat. Four sets of eight.

The foregoing takes care of Monday and Thursday. Forget running on Monday and Thursday and Tuesday and Friday, your follow-up days. You won't have the gas.

Tuesday and Friday are as follows:

1. Bent-arm pullover. Lie flat on the bench, keep the forearms at a 45 degree angle to the upper arm, the elbows close together, and lower the weight to the ground. Raise and repeat. Five sets of eight.

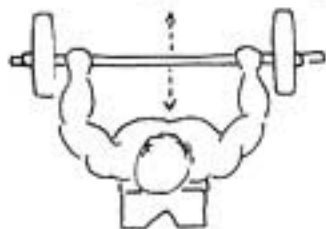
2. Tricep pushdown — five sets of ten with palms down grip, five sets of ten with palms up grip. The pulley necessary for this can be purchased at any hardware store and mounted on the wall (illustrated). If you want a monster set of arms don't skip this exercise. Keep the elbows in close to the sides and don't use bodyweight to swing the weight.

3. Concentration Curls. Sit down and do one dumbbell curl between the legs with one arm at a time. Four sets of eight.

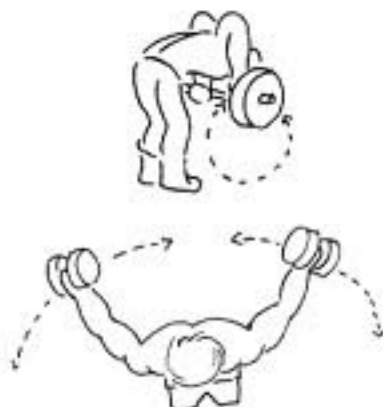
4. Incline dumbbell curls. Prop one end of the bench up on a washtub, stair, or what-have-you to achieve a 45 degree angle for the bench. Grasp a dumbbell in each hand and lie down on the bench. Let the arms hang over the bench perpendicular to the ground with the palms pointing inward. Curl the weight upwards and twist the hands gradually until the palms are toward your face. Keep your head flat on the bench. Four sets of eight.

Take thirty seconds between exercises — just enough to catch a little air and a small sip of water.

Wednesday and Saturday do two sets of front squats (page 216) of 15 repetitions each and do your running. You'll



seldom find running mentioned in the muscle magazines but do it anyway and keep in mind one thing — barbells and protein can be peddled; running can't.



TRAINING FOR ENDURANCE

By Mike Brown

You have probably all seen the movies and TV shows where the Desert Apaches run for fifty miles and then spit out the mouth full of water that they had started with. Impressive feat. There aren't too many men today who can duplicate it but YOU can if you want to and are willing to train for it. Certain basics have to be followed.

First, you have to remember that the Apaches ran barefoot. That may seem like

a relatively trivial matter but in fact it's a major factor. The nerves in the feet travel to all the major organs of the body and the gently pressure of grass and dirt on those nerves as you run tends to "adjust" those nerves and consequently the internal organs in much the same way a chiropractor manipulates the spinal column for other problems. It's called Zone Therapy and stay tuned, the whole ball of wax will be along in a following article. The bare skin on the bottom of the feet also tends to absorb chlorophyll from the grass and trace minerals from the dirt (or mud) and said goodies then work themselves into your bloodstream. Always check your running area over before you start very, very carefully. Rusty nails and doggie poop can also get into the bloodstream. Golf courses are a good place to run if you can get there early enough in the morning to avoid disgruntled security personnel and flying golf balls.

Second, when you are going for a maximum distance, you have to develop a "rhythm"—that is run at the same speed that feels like a natural movement and maintain that speed exactly. You can often run twice as far "in the groove" as opposed to varying your speed. You can prove this to yourself by running two miles or more at the same speed and then walking. Your legs will, of their own volition, continue the same movement pattern they had while you were running. What happens is the muscles and the organs that feed them (heart and lungs) tend to "co-ordinate" with each other to conserve energy. You'll notice most of those Apaches had a long, loose stride and none of them would have won the hundred yard dash.

Run for distance once a week. Train two days. The other day you train run at different speeds, run sideways like a crab, and backwards. If you run only in one direction at one speed that is all you will be capable of. I made that mistake and got up to a 4 mile run with a rhythm and then found to my embarrassment that, running as fast as my fat little legs would carry me, I couldn't make it even 400 yards.

When you start running out of time and your training is taking too long get yourself a weighted vest or even a set of wrist weights. Never put weights on your ankles. It's too easy to pull the long inner thigh muscles between the knee and the groin by so doing. Put just enough weight in the vest to where you can barely feel it—like a pound at a time. When you can run five miles with a pound of excess iron then add only one pound more. When you can run five miles lugging fifty pounds and your diet, other exercise program, and

rhythm's right you should be able to run 50 miles non-stop (there's a 70 year old man in Los Angeles who runs to Las Vegas non-stop occasionally, named Fred Grace, writes articles for Iron Man Magazine and if he can do it so can you—run, I mean).

Two days a week is not the whole exercise program. You'll need some work with a barbell and a set of iron boots or a dumbbell. One of the best conditioners for distance running is high rep barbell squats—100 or more non-stop. Place the bar on your shoulders as you simply will not be able to hold it in front of you as previously illustrated. Start off with 100 lbs. and do not increase the weight, only the repetitions. Wrap a towel around the bar to keep it from cutting off you



circulation. A marathon runner years ago did only this one exercise during the winter and won everything he entered in the spring.

Swimming is another good exercise for endurance training but you need professional instruction—otherwise you'll never get the rhythm right. Once you become proficient swimming you can get yourself a boat or something to tow around to increase your power. Don't use weights for obvious reasons.

We have already discussed diet in previous articles concerning honey and dessicated liver (which should be part of any endurance diet) but there are a couple of things that need mentioning. For a 50 mile run you're going to have to work up to ¼ lb. dessicated liver a day, 8 oz. of

honey, and if you intend to test your endurance by seeing how far you can walk across country rig up several 8 oz. honey bottles in an ammo pouch with metal coverings (illustrated) and sip honey and water once an hour as you go—you should be able to march five days without sleep and cover about 300 miles. The Roman legions used to travel like that and in addition carried four basic grains (corn, barley, wheat, and rye) that they munched on while on the move.

While on your endurance training program stay away from all fat meat, starch, and milk. Fat meat keeps you from digesting lots of other good stuff, the starch mostly doesn't digest at all (if you swallow an open safety pin the recommended procedure for dislodging it is to eat white bread, the stuff forms a lump around the pin and passes out of the system), and milk tends to react with the smog in the atmosphere in your lungs and makes it hard to breathe. You won't notice it until you are breathing hard—and then it feels HORRIBLE. I found this out the hard way while I was working for Arrowhead Water Co. in Los Angeles about 1968—I'd start off humping 60-lb water bottles up and down stairs about 8 in the morning, feel fine at 10, grab a quart of milk at 10:05 and gulp it down, and by 10:15 have to lay down in the cab of my truck to catch my breath. An occasional glass the night before shouldn't hurt but any more than that is going to cut your wind.

Go heavy on the fresh fruits and vegetables and light on the water. Despite all the "six glasses a day" nonsense that fact is that water washes stuff right out of your system—including but not limited to protein, vitamins, minerals, and all the rest. Drink only when you're thirsty; never force it.

And remember, those Apaches weren't built like Mr. America either. You're subject to lose weight. Size and strength is for those who like to stand and fight. Endurance is for those who want to leave the squabbling to others.



FORCED REPS

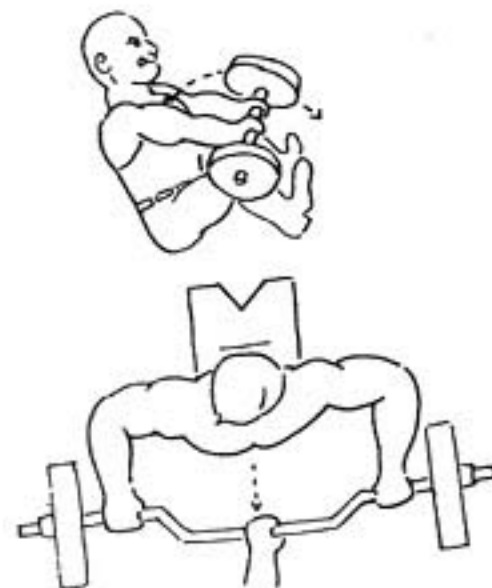
By Mike Brown

Certain of the principles and "facts" described in this article may not be as accurate as they could be. In fact, every premise and line of reasoning I expound may be totally inaccurate. However, there is one over-riding consideration that outweighs whatever mis-statements I

make—regardless of the facts, it works. For RAPID increase in both muscular size and strength "forced reps" are simply the absolute best way of working out; the most result-producing.

And results are what count. For a similar erroneous scientific principle developed to the point of workability, consider the gasoline engine as we know it. The present gas engine was developed from the 19th century steam engine, designed to operate on expanding gasses. The problem is that gas doesn't expand, it explodes. The hydrogen in a hydrocarbon fuel lights off at 3000 ft. per second (the same as nitroglycerine dynamite) but the carbon only expands at 75 ft. per second—only slightly more rapidly than steam. So what our "experts" did was fill gasoline full of additives to keep the hydrogen from going off (the "ping" you hear using low grade gas in your engine is small amounts of hydrogen igniting). If General Motors can run a steam engine on gasoline have faith, my principles may be unsound but the system works regardless.

The first dubious principle I'm going to have to ask you to accept is that muscles have to be worked to the point of absolute failure for rapid growth. There is an "all or nothing" theory of muscular contraction that goes like this: all the muscle fibers are attached together like a chain of paper clips. Each chain either works or it doesn't. Let's imagine a muscle of 1000 fibers or chains. With a 10 lb. weight hung on the end of it from full extension to full contraction 100 fibers (or chains) are utilized and the other 900 get no work at all. Which means that, should the 100 fibers double themselves in size through work, the total muscular area of the entire muscle would only increase 10%. On the other hand, if a method could be found of involving all 1000 fibers and those fibers all doubled in size the total effect would be a 100% increase in size of the muscle.



The second principle you must accept is that to achieve the total involvement of every fiber the muscle must be overloaded—in other words, it must be forced to lift either more than it is capable of or—to the literal ounce—exactly as much as it is capable of and no less. The problem here is that the strength of a muscle varies from day to day, from exercise to exercise, and from repetition to repetition while the weight on the barbell remains relatively constant.

The third principle you must accept is that muscle cells must literally be ripped apart to insure growth with a rehealing and a little added "extra" for the next time demands are placed upon them. At full expansion a muscle cell "tears" and at full contraction, because it is crowded too much, it "explodes." If the muscles can be worked in such a brutal fashion without unravelling the ligaments growth is almost instantaneous (presuming, of course, a proper diet). Such a method is brutal and is most emphatically not for beginners. If you haven't trained for at least three months on the previous routines I gave you and try this one the lunch you lose is no-one's fault but your own. You will get sick.

The fourth principle you must accept is that you will need a training partner. And here's how it works.

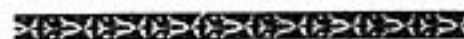
Let's start with the bench press. Do one warm-up set. Then one set with a medium-heavy weight. Then one set in which about all you can do is 6-8 reps. Now the fun starts. Load the bar past a weight you know you can't lift. If your best bench press is one rep with 290, put 300 on the bar. Have your training partner grasp the bar in the center and instruct him to pull lightly on the bar as you shove it back up—only enough to keep you from slowing down or stopping. Since you know the weight is going back up there is no problem with mental blocks ("I can't do it") and there is always that friendly nudge to help you over the "sticking points." You'll find that you'll probably get about six reps like this with a weight you normally couldn't get off your chest. You should also find that your training partner is giving you too much help to start with. A lot of weightlifting is mental, more so than you would think.

The proper way to do a bench press is lie flat on the bench, hands shoulder width apart, palms toward the face as in a regular military press, inhale deeply before you lower the barbell and exhale as it travels up. Basically the same breathing pattern as used for squats. Do six sets, a warm-up, medium, heavy, two sets of forced reps, and one of about 20 reps to finish off. If you are flat-chested (or are

trying to cure your wife or girlfriend of the same problem) use a bent bar (illustrated) so the deep-seated muscles of the pectorals are called more into play.

You will only need two other upper body exercises—chins on the bar and bent-over rowing motion. Have your training partner boost you by the derriere to achieve the same effect of the forced reps when you slow down and just "unwind" with the rows (illustrated). Four sets of chins and two of the rowing motion. Three days a week. If you keep making progress you may be able to keep this routine up for four to six months. After that you run into the law of diminishing returns—routines have to be varied or the body stagnates.

Try this routine and you will see that it works. Just keep in mind that physiology is a very inexact science, if we knew what we were supposed to we could collapse the magnetic fields surrounding the nucleus atoms keeping our electrons at bay and slide through solid walls, breathe underwater, discharge electricity from our fingertips, and do all sorts of other fun things. Until then we go with what we got (or at least know how to use).



(Continued on Next Page)

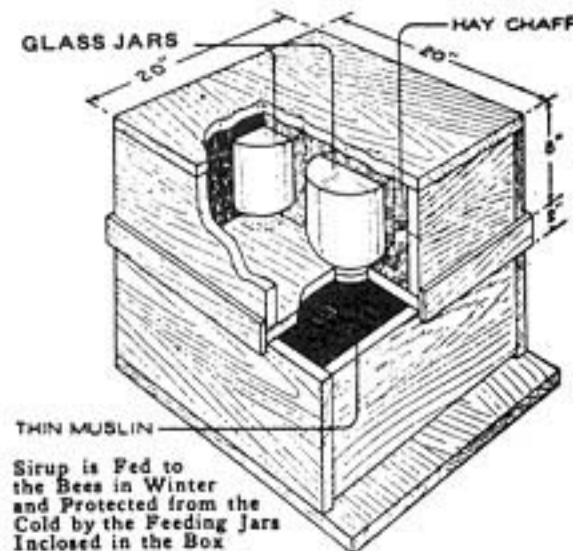
BEE FEEDER FOR WINTER USE

From Popular Mech. 1919

The use of a feeder, like that shown in the sketch, makes the feeding of bees in winter convenient. Sirup is fed to the bees from inverted glass jars, the openings of which are covered with muslin, the jars being incased in a packing of chaff in a wooden covering. The wooden box is made to fit over the hive, as shown in the sketch, and a 2-in. strip is nailed over the joint.

The device is made as follows: Use wood smoothed on both sides; pine, basswood, or other soft wood being satisfactory. Make two pieces, $\frac{7}{8}$ in. thick, and the same size as the top of the hive. Into one of these cut two round holes, as shown, to fit the necks of the jars. Make two pieces, $6\frac{3}{4}$ in. wide, for the sides, and two for the ends, the length being suited to the hive, the dimensions given in the sketch being suggestive only. Make four strips, 2 in. wide, and long enough to fit the four sides of the box. Nail the pieces of the box together, as shown, nailing the sides over the end pieces, and the top over the frame of sides and ends. Pack chaff into the box, and, after filling the jars with

sirup and covering their openings with muslin, pack the jars into the box so that their openings will be level with the bottom through which the holes have been cut. Fasten the board, with holes for the jars, into place with screws, so that it may be removed when it is desired to remove the jars for refilling. Nail the 2-in. strips around the lower edge of the box so as to cover the joint between the box and the hive. The feeder is then fitted into place, the bees feeding from the surface of the muslin. The chaff prevents the sirup from congealing in cold weather and so it is always available

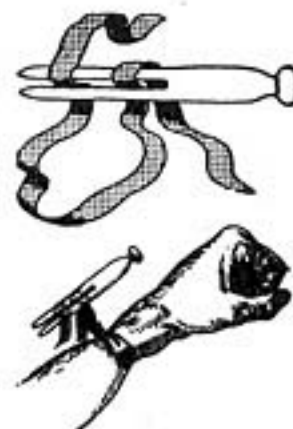


for the bees. The use of this simple device will prove economical and practical in keeping bees over the winter, assuring them a good food supply, with little effort on the part of the keeper.

An Emergency Tourniquet

Popular Mechanics 1915

A valuable addition to any shop medicine cabinet is the tourniquet. A device that will answer the purpose of the tourniquet can be made from an ordinary clothespin and a piece of binding tape, about $\frac{3}{4}$ in. wide and 14 in. long. To stop the bleeding from a wound on a limb, pass the tape around the injured member between the wound and the blood supply. Pass the tape through the slot in the pin, wind the ends around the pin two or three times to prevent slipping, then turn the pin to draw up the tape tightly until the flow of blood is stopped.



MUSCLE GROWTH

By MIKE BROWN

There are a number of commonly-held theories of what causes muscular growth. As I pointed out in a previous article, most of them are erroneous. Which is why most of the folks who try to train with barbells never get anywhere. As I also mentioned previously, protein does not put weight on you—it takes it off. Yet protein also builds muscle. Sounds like a paradox, doesn't it?

Not really. Muscle tissue is porous, like a sponge. Fat is more or less solid, like jello. Which is why a man with 200 pounds of solid muscle can look like a gorilla and one with 200 pounds of solid fat merely looks like an average sized slob. So don't get disappointed if you only gain five pounds of muscle in three months. To get an idea of what five pounds of muscle really is, take a five pound roast (you more affluent types) and hold it in your hands. Pretty big, isn't it? Now THAT is five pounds of muscle. And one more thing. Muscle tissue by weight comprises only 15% of an individual's total (normal) bodyweight. In other words, if a 170 lb. man gains 25 1/2 pounds of muscular bodyweight he has doubled his amount of muscle tissue.

And doubling the amount of muscle tissue in a given individual simply isn't that hard if the proper diet is followed. As I also mentioned in a previous article, diet is 80% of the program. Yes, you will require protein—but if you use it the way I tell you it won't burn all the fat off your bones.

Food is like gasoline. What it does is dependent on how it's used. You can make a molotov cocktail out of it. Or turn it into fumes and explode it. Put it in a Honda minibike and travel a hundred miles with it, put it in your Detroit canoe and drive down to the corner store, or put it in the punch for fun at parties. A gallon of gasoline has the potential energy to lift a 3,000 lb. automobile six miles into the air. It's all in how it's extracted. And what you have to do is extract as much as possible from the food you eat while minimizing the effort caused the digestive system.

The oranges with each meal, mentioned in another article, do the digesting you need. To make it easier for those oranges to do the job, cut out almost all bread products. Two slices of whole wheat a day are the limit. No more. No less than four slices a week. A complete lack of wheat affects the central nervous system. You'll find that once you cut out the bread your endurance will increase 30% almost overnight. And to further aid the digestive system, run. It speeds up the metabolism which in turn increases the

appetite. Also, the running keeps the body "loose" and helps prevent sprained muscles, back problems, and other annoyances. But if you're trying to gain weight, don't overdo the running. Once or twice a week is fine. I went from 217 to 224 in one month running only one day a week—the first week 2 1/2 miles was my best shot, the fourth week I made it 4 miles and probably could have gone further if I wanted. Training every day is for the simple-minded.

Don't stuff yourself. Eat only when you're hungry. And four meals a day is adequate—breakfast, lunch, supper, and a quart of milk with the mandatory orange for a bed-time snack. Don't eat between meals. Give the digestive system a chance to work.

When you take protein, eat it sparingly. And when you eat it (whether in the form of steaks, cheese, eggs, or protein powder) be sure to have some sort of fat to go with it. The best is probably coconut mash—coconut meat and milk stuffed into a blender and liquified; chill before drinking. It takes about thirty coconuts to provide a gallon a day of this goo. The fellow who taught this little gem to me discovered it in 1958—his bodyweight went from 180 to 225 in six weeks and his bench press increased from 180 to 360.

Unfortunately, unless you are figuring on a trip to the South Seas or Central America the costs of coconuts is prohibitive. I understand that coconuts are now 75 cents apiece which means if you want to gain 50 lbs. in six weeks it's going to cost you \$1012.50—not counting the aggravation of splitting the coconuts and drowning the garbageman in husks. A little impractical. Somewhat, somehow somebody must have canned this stuff economically. However, until we find out who, where, and for how much we'll have to use a native substitute for this gook. The potato.

Normally, potatoes are starch—if they're cooked. We're going to consume ours raw. Raw, potatoes are more of a fat: if prepared properly. Which means we squeeze the life out of them and make a juice. A simple home-made device for squeezing potato juice is illustrated. Wash your potatoes first. Leave the skins on. Stuff one at a time in the device. Squeeze. Drink the liquid immediately. Rather than belabor the reasoning behind "immediately" try a simple experiment—cut a potato into thin slices (raw) and expose to air. The slices turn black almost at once. The juice will rot even quicker.

The finished product should be a murky liquid with a brownish cast to it. The taste

is horrendous—sort of like very dirty and very salty thick swamp water. However, it provides a tremendous source of minerals in addition to the fat and if you happen to have an ulcer the juice will coat it much more effectively than milk.

Another outstanding item is a type of seaweed grown off Jamaica called Irish Mash. Last I heard it was available from the American West Indian Store, Nostrand & St. Marks, Brooklyn, New York. It's boiled with linseeds (not linseed oil), strained through a cloth to catch the seeds, and then let cool into a pudding. As close as I can figure out it provides all the trace minerals and vitamins our diets are normally deficient in. The guy I learned this one from went from 155 lbs. to 210 lbs. in six weeks eating one bowl a day. The problem was, he wasn't lifting weights along with it. Irish Mash is primarily used as an aphrodisiac and he just got hornier and chubbier.

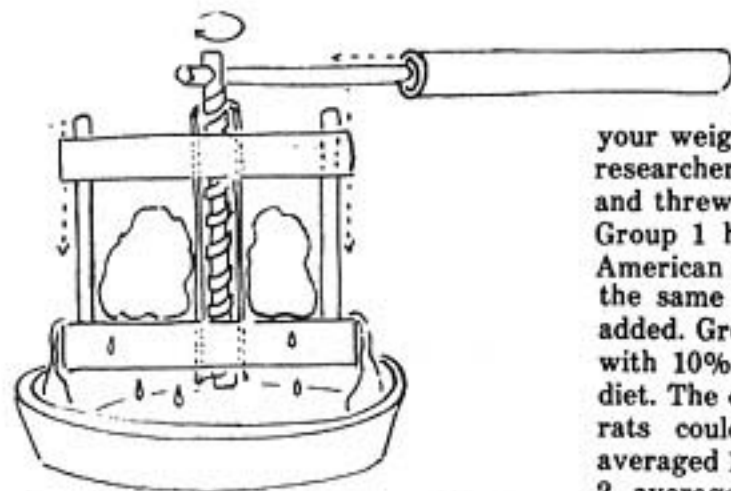
Irish Mash is rather cheap (about \$3.00 for a month's supply) but it may not always be available. There are a couple of substitutes. One is kelp (mere powdered seaweed) which, while not quite as effective for weight-gaining as Irish Mash, is just as good for endurance, energy, and preventing staleness. A five pound container from the average health food store will run less than five bucks—and two teaspoons a day will last you for months. And when civilization collapses?

Grass. Not to smoke, not marijuana, to eat. If you care to believe the Biblical account, Nebuchadnezzar lived on the stuff for 7 years. Unfortunately, we are not told how his physique was affected but it appears to have helped his mental problems. In more recent times many mountain folk have cured all sorts of physical ailments with it. To be really effective it needs to be juiced, like the potato.

It is really ironic that grass is not looked on as a food in this country. But then, folks in Europe have starved to death next to whole barns full of corn and potatoes because they thought only animals could eat them.

Another often overlooked item is honey. While it will not bulk a person up by itself it goes right into the bloodstream for immediate use as energy and leaves the other food for tissue building. A man in Massachusetts proved this several years ago by eating three square meals a day and sipping an 8 oz. bottle of honey all day long. He gained 20 lbs. in 10 days and placed third in the Teenage Mr. America.

Honey has another use very seldom mentioned: it is probably the best burn ointment available. Slap the honey on quick enough and the burn leaves no scars.



Dessicated liver is also one of the best. Dessicated liver is normal beef liver with all the fat and moisture content removed and made into a powder. Don't ask me how it's done; I wish I knew. Liver from almost any slaughterhouse is in the neighborhood of 50 cents lb. Dessicated the cost runs \$3.00 per pound plus. Fortunately, not very much is required. A spoonful half an hour before each meal increases the appetite enormously and provides all sorts of growth goodies: B vitamins, iron, P-450, etc. A cupful a day (about 4 oz.) and you'll be able to whip

your weight in wild cats. Back in 1950 a researcher filled three tubs full of water and threw three groups of rats in them. Group 1 had been fed on the standard American diet. Group 2 had been fed on the same diet with B complex vitamins added. Group 3 was fed on the same diet with 10% dessicated liver added to the diet. The object was to see how long the rats could keep swimming. Group 1 averaged 15 minutes and drowned. Group 2 averages 30 minutes and drowned. Group 3 was still going strong at the end of four hours and the researcher fished them back out of the water and terminated the experiment.

Finally, stay away from all fat meat (pork, greasy hamburger, etc.), scavengers (like shellfish, they pick up industrial wastes), refined sugar, and all artificial junk (coke, candy, etc.), and go heavy on the lean meat, cheese, milk, potatoes (with skins), roots, leafy vegetables, and fresh fruits. With such a diet and what I've just told you becoming a monster should be easy.

PRUNING A PEAR SHAPE

By Mike Brown

The pear shape is quite common. Especially where large herds of office workers gather to graze—Chicago, New York, Denver, and so on. Everybody recognizes it: narrow shoulders, wide hips, corpulent abdomen, two large pouches of lard attached to the derriere, and fat thighs tapering down to anemic calves. A lot of people have such a shape. But nobody will admit it.

Simply losing weight is easy. Unfortunately, getting rid of a pear shape is a major project and horribly frustrating if not done properly. Especially for a fellow trying to add muscle in the process. Here's why.

First, it is almost impossible to gain size and strength and lose unwanted fat at the same time. Human physiology doesn't work that way. Compare it to a balloon. You fill the balloon with air (as you fill the body with food) and the balloon expands all over. The air (or food) simply goes where it wants to; not where you want it to.

Second, tremendous strength comes from the least obvious places—the upper legs, lower back, and the midsection. For a typical example of this, look at all the top weightlifters—Paul Anderson, Aleksev, and so on. Santa Claus in a sweatsuit. Body beautifuls they are not.

Third, you have to make up your mind whether you want a really "trim" waist or if you would rather have the "washboard" effect so sought after by the Mr. America types. Unless you inherited the bone structure to make it possible you can't have both. Muscle that has been built up simply has to take up space—meaning you are going to have to let your belt out a couple of inches.

Basically, all this boils down to is this: if you try to use conventional methods to reduce, you'll wind up with narrower shoulders, smaller arms, possibly an inch or two off the waistline, no appreciable amount of lard off the butt, cellulitis, and a tired, lethargic feeling. Here's how we avoid it.

Your regimen will have to have two segments: diet and, of course, exercise. Certain exercises are super no-no's for any type of waist program, but for some reason the average yo-yo does them anyway. The first and probably the worst is the sit-up. They may be alright for prizefighters concerned with warding off blows under the heart but for reducing they don't work. Basically, sit-ups thicken only the muscles directly under the sternum and push the upper wall of the abdomen out. If you must do situps, do Roman Chair style (illustrated). The next worst is the side-bend (illustrated). They are alright for "firming up" an area but the muscles affected, the external obliques, have a way of growing like Steve McQueen's old nemesis of the movies,

THE BLOB. In other words, start doing side-bends with anything other than a very light weight and you're going to have flaps sticking out of your side like the ears of Dumbo the Elephant.

The exercises you should be doing are as follows:

1. Dumbbell Swing (illustrated). Use a very light weight. This is simply a warm-up to protect you from injury and allow you to work at your maximum capacity for the rest of the workout. Do one set, about twenty repetitions.

2. Leg Raise (illustrated). Do four sets, ten repetitions each for a starter. Then the next time do fifteen reps per set. And so on until you have reached a hundred reps for each of the four sets. It is extremely important to break the work up into sets. Remember, each workout is not a "contest" to see what you can do. Roger Bannister proved this when he trained for the four minute mile—he would run full bore for 440 yards (a quarter mile), jog the next 440, and then full bore for another 440, and so on. Once you get to the four sets of a hundred reps each, get a barbell plate with a piece of rope and start over (illustrated).

3. Our old favorite, the hyperextension (illustrated). Two sets of fifteen and then start adding weight.

4. If you can get ahold of a pair of "iron boots" do knee-ups, two sets of twenty. Practically every solid iron barbell set made in the U.S. comes with a set and you should be able to slick the neighbor's kid out of his for a couple of bucks. This particular exercise gets the muscles deep in the abdominal cavity like nothing else can. When two sets of twenty starts getting easy run back over to the neighbor's kid and see if you can't slick him out of the dumbbells to stick through the holes in the iron boots to increase the weight. When doing the knee-ups be sure to aim the left knee at the right shoulder and right knee at left knee on the way up (illustrated). Otherwise you not only will not work the muscles deep in the abdomen but will wind up simply with exhausted thigh and groin muscles.

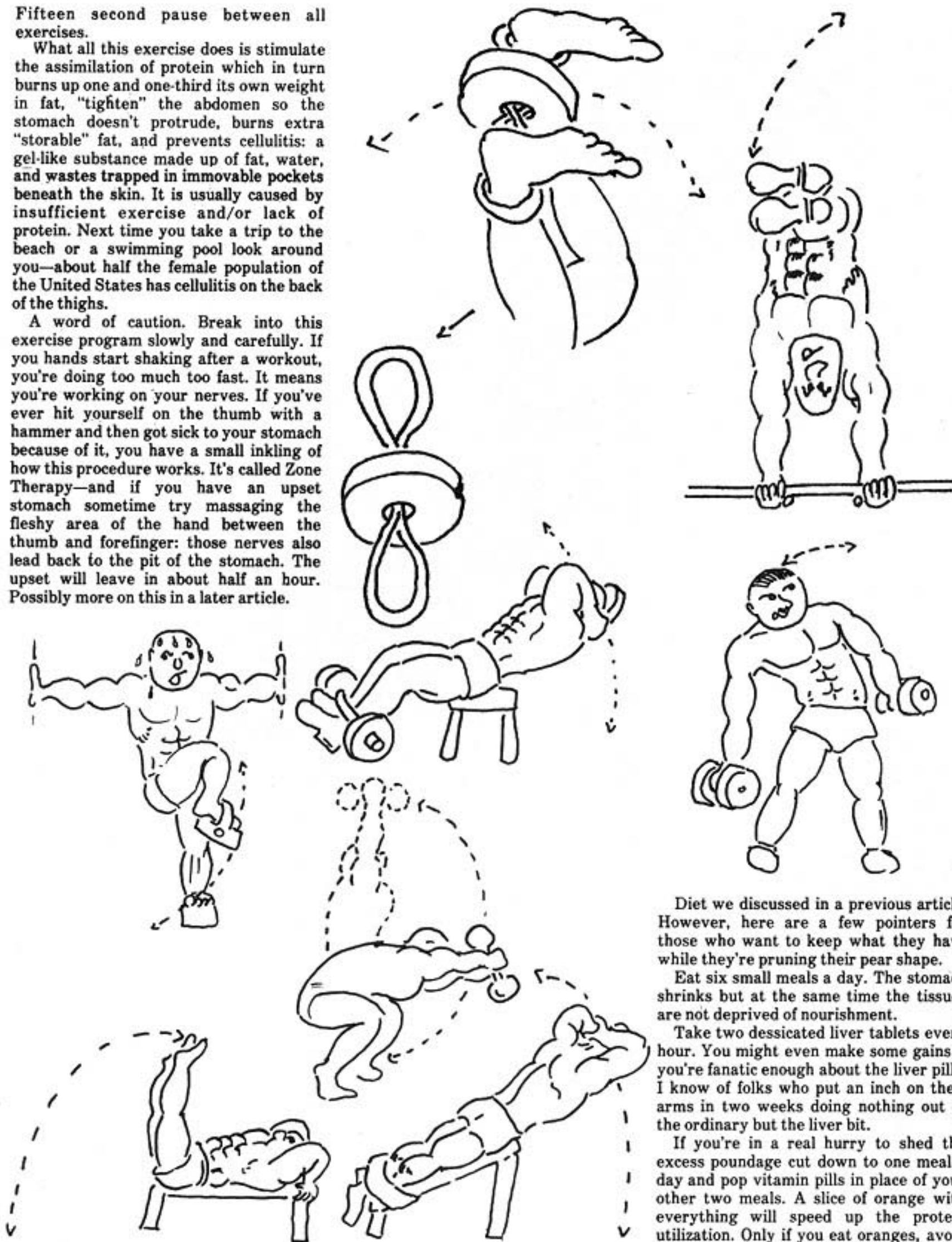
5. Hanging leg raises. Grab an overhead bar (chinning bar) and raise the legs—only try to twist the feet so that the left side of the left foot (keep feet together) is parallel to the ground on one rep and then the right foot on the next rep, alternate (illustrated). This works the side muscles (external obliques) without enlarging them. Work up to two sets of twenty.

For the rest of your program I would suggest two sets each of squats, upright rows, military press, and curls. Don't strain, all you're trying to do is maintain previous gains. About eight reps each.

Fifteen second pause between all exercises.

What all this exercise does is stimulate the assimilation of protein which in turn burns up one and one-third its own weight in fat, "tighten" the abdomen so the stomach doesn't protrude, burns extra "storable" fat, and prevents cellulitis: a gel-like substance made up of fat, water, and wastes trapped in immovable pockets beneath the skin. It is usually caused by insufficient exercise and/or lack of protein. Next time you take a trip to the beach or a swimming pool look around you—about half the female population of the United States has cellulitis on the back of the thighs.

A word of caution. Break into this exercise program slowly and carefully. If your hands start shaking after a workout, you're doing too much too fast. It means you're working on your nerves. If you've ever hit yourself on the thumb with a hammer and then got sick to your stomach because of it, you have a small inkling of how this procedure works. It's called Zone Therapy—and if you have an upset stomach sometime try massaging the fleshy area of the hand between the thumb and forefinger: those nerves also lead back to the pit of the stomach. The upset will leave in about half an hour. Possibly more on this in a later article.



Diet we discussed in a previous article. However, here are a few pointers for those who want to keep what they have while they're pruning their pear shape.

Eat six small meals a day. The stomach shrinks but at the same time the tissues are not deprived of nourishment.

Take two dessicated liver tablets every hour. You might even make some gains if you're fanatic enough about the liver pills. I know of folks who put an inch on their arms in two weeks doing nothing out of the ordinary but the liver bit.

If you're in a real hurry to shed the excess poundage cut down to one meal a day and pop vitamin pills in place of your other two meals. A slice of orange with everything will speed up the protein utilization. Only if you eat oranges, avoid

milk. And eliminate starch in any event. Go heavy on the eggs, fish, poultry, and greens. Bananas, corn, and many types of beans (e.g., lentils) will, if eaten with a little meat, have a tendency to keep your weight up. Without meat, all they do is give you gas. And don't try doing without

meat—all you get out of a vegetarian diet is a vitamin B12 deficiency. Also, stay away from all fatty and/or fried foods. And carbonated beverages: soda pop has a tendency to prevent protein digestion. If you know anyone addicted to cola drinks weighing in over the 200 mark you know

what I mean.

Try to run a couple miles twice a week to stay "loose". Stay on this program for six weeks or so. With a little effort and studious attention to directions you should whack off four to six inches from around the beltline.

ZONE THERAPY

By Mike Brown

Centuries ago folks got sick and had other medical problems just like we do today. The medical profession would have us believe that our increased longevity is due to their professional competence and expertise. The state of the art of medicine is supposed to correlate directly with the increased lifespan.

Guess again.

An interesting book was once published on "How To Lie With Statistics." Given enough raw data and a little licensing in arranging it you can prove almost anything you want about anything you want. In the case of the medical profession they stuffed the infant mortality figures from previous centuries into their data and as a result everybody's average lifespan went down. Back in those days weak infants were eliminated by natural diseases. Today they are kept alive until they can become weak adults.

Fact is, cancer and other such diseases that were virtually unknown in the 19th century have reached almost epidemic proportions today. What's the problem here?

The problem is that the study of medicine is the study of medicine—or how chemicals react in the human body—not the study of health. Added to that is the American Medical Association; an organization far more concerned with money than it is with medicine. We laugh today about the medieval methods of "bleeding" the patient to get rid of the "bad blood" and find it perfectly logical to let the modern physician bleed us of our life savings for such silliness as radiation treatments when the patient is going to die anyway.

Since the best things in life are free it stands to reason that it is hard to make a buck off of them; meaning the A.M.A. and other such outfits are going to do everything in their power to suppress or ridicule them or intimidate their advocates. The laetrile controversy is a perfect example; whether it works or not is immaterial since it has never hurt anyone and yet the A.M.A. has literally moved heaven and earth to prevent its

acceptance into the United States because it "hasn't been proven to cure cancer." Neither has radiation, chemotherapy, and the other standard A.M.A. recommended treatments.

Enter acupuncture. The A.M.A. scoffs at it because there is not enough money to be made at it. The Chinese have been practicing it for over 2,000 years so either there must be something to it or the Chinese are history's slowest learners.

And what acupuncture is is a crude form of zone therapy. Yet the major tool for zone therapy is much more readily available than the gold and silver needles used in acupuncture—the human thumb. The right pressure with the thumb results in all sorts of fantastic things happening. As I mentioned in a previous article, hitting the thumb with a hammer will make you sick to the pit of your stomach—because the nerves in the thumb itself lead to the abdominal cavity. Instead of using a hammer the next time you want to do something with your thumb to test this theory out wait until you have an upset stomach. Massage the fleshy part of the hand between the thumb and index finger. Either or both hands. In about twenty to thirty minutes the pain should have vanished.

Imagine for the sake of convenience that your nerves are like flexible tubes leading from one part of your body to another. If a tube is "pinched" whatever backs up the tubes causes problems at the point it can't back up any further. This is grossly inaccurate and unscientific but there simply isn't any other way to explain it. Electrical impulses flow along the body's motor pathways (nerves) and any interruption causes problems. If an impulse can be "unblocked" or freed to travel the problems of the organs involved usually iron themselves out. And "unblocking" is done by direct applied pressure.

Zone therapy has been around for centuries but it wasn't until the early 1900s that it was systematized by a Dr. William H. Fitzgerald, M.D. The Doctor was an ear, nose, and throat specialist

and found that he could use pressure on various parts of the body to deaden the pain of his patients in place of the cocaine normally in use then. He figured out that the body had ten "zones", five on the left and five on the right—each zone or "line" ran through a corresponding finger or toe. For example, zone one ran (or runs) completely through the body and loops through the thumb and big toe—any problem arising from between the eyes down to the groin (the middle of the body) was helped by the massage of zone one (the thumb). A gross over-simplification but necessary to grasp the concept.

Dr. Fitzgerald wrote a rather lengthy, detailed, and involved book on his findings over half a century ago which is still printed by Health Research, 70 Lafayette St., Mokelumne Hill, California. Not too many of the members of the medical profession buy it.

One of the Doc's theories was that since Western Man was such an inveterate wearer of shoes the feet were kept in tender condition ideal for zone therapy. The same nerves go to the hands but since the hands receive so much more use hand massage simply is not as effective.

What the Doc originally started with was not zone therapy but pressure analgesia—or anesthesia by pressure. Eliminating pain and curing conditions are not the same thing.

For eliminating pain a little more equipment than just the thumb is needed. Such as rubber bands, clothespins, and aluminum combs. The rubber bands and clothespins cannot be left on too long or weakness and irritability results. Clothespins put on the end of the fingers will (sometimes) anesthetize the mouth (as for dental work). Be careful playing around with rubber bands, get them on too tight and leave them on too long and circulation stops.

For those of you intending to make a living as mid-wives in the New Age when Blue Cross and the A.M.A. has ceased to exist an account is given by Dr. Fitzgerald of how to do it:

"The woman I delivered was a primipara (one who had never had a child before, and who, therefore, because of the rigidity of the bones and tissues, has a more difficult labor), small in stature.

When contractions began, and the mother was beginning to be very nervous and complained of pain, at which time I generally administer chloroform, I began pressing on the soles of the feet with the edge of a big file, as I could find nothing else. I pressed on the top of the foot with the thumbs of both hands at the metatarsalphalangeal joint (where the toes join the foot). I exerted this pressure over each foot for about three minutes at a time. The mother told me that the pressure on the feet gave her no pain whatsoever.

As she did not have any uterine pain, I was afraid there was no advancement. To my great surprise, when I examined her about ten or fifteen minutes later, I found the head within two inches of the outlet. I then waited about fifteen minutes, and on examination found the

head at the vulva. I then pressed again for about one or two minutes on each foot, and my thumbs over the tarsal-metatarsal joints as before. In this way I exerted pressure on the sole of the foot with the file, and pressure on the dorsum of the foot with my thumbs, doing each foot separately. The last pressure lasted about one and a half minutes on each foot. Within five or ten minutes the head was appearing, and I held it back to preserve the perineum (the tissue joining the vagina and the rectum). It made steady progress, the head and shoulders coming out in a normal manner. Within three minutes the child—which weighed in at 9½ pounds—was born, crying lustily. The mother told me she did not experience any pain whatever, and could not believe the child was born. She laughed and

said, this is not so bad.

Another point that is very remarkable is that after the child was born the woman did not experience the fatigue that is generally felt, and the child was more active than usual. I account for this on the principle that pain inhibits progress of the birth, and tires the child. But as the pain was inhibited, the progress was more steady, and thus fatigue to both mother and child was avoided."

There is much more to zone therapy than even touched on here. Renew your subscription for more zone therapy, iradiology, water cures, fasting, and other goodies the A.M.A. and the Rockefellers (chemical companies) have done their best to consign to the trashbin of history.

ZONE THERAPY—PART II

by Mike Brown

Even among those who have enough money to take better care of themselves and the folks rich enough to hire someone else to do their thinking for them, really good health is a rarity. The most athletic looking and healthy appearing individuals are very seldom as well off as they look. Most will admit to a twinge of back trouble, a touch of rheumatism, stomach, liver, or kidney trouble; nervousness, headaches, neuralgia, constipation, or something that tends to prevent what we refer to as perfect health. That's just the men. With women the healthiest of them are in a condition that almost defies the laws of physics, chemistry, and biology. Over three decades ago, when this country was sending hundreds of thousands of well-armed and well-trained men overseas to fight the Second World War, those men took with them a pin-up of a girl who had atrophied leg muscles, the American ideal: Betty Grable. Take a good close look the next time you see your favorite actress on the TV. At first glance a lot of them have fantastic physiques — but if you look real close you'll find a lot of that is done with push-up bras and pull-in corsets.

Why are they in such horrendous shape?

Two basic reasons:

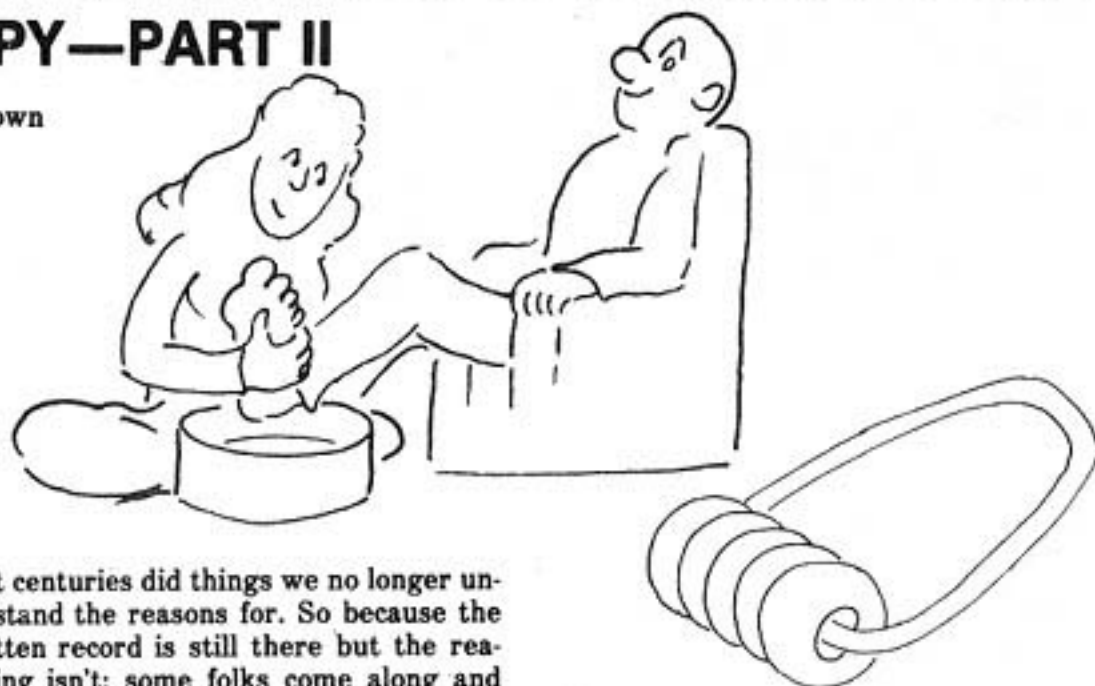
First is the private club of doctors and lawyers our entire government is run by. Go to your local Post Office sometime and observe all the "Laetrile is Worthless; Laetrile is Dangerous" nonsense plastered all over the walls.

The second reason: our own laziness and inability to pay attention. People in

past centuries did things we no longer understand the reasons for. So because the written record is still there but the reasoning isn't; some folks come along and make a religion or a ritual out of something that at one time actually made sense.

One of these is the foot-washing and anointing with oil business mentioned in the Bible. It's not too popular with a lot of "religious" folk possibly because of the large numbers of church-goers with brobidrosis (smelly feet) but it does have some value. Try these experiments.

Next time after a hard day's work you feel like your feet are going to fall off, tired, aching, sweaty, pour a couple gallons of hot water in a tub and add a cup full of powdered milk to it. Insert your feet. Let soak for about fifteen minutes. The powdered milk should work its way into your pores and perk up your feet and legs and relax the rest of you. If your better half is a long-suffering type get her to massage the bottoms of your feet with her thumbs in circular motion afterwards. The feeling you get has to be experienced to be believed.



Next time try just having your mate working your feet over with olive oil. In a book titled **ELECTRONIC POTENTIALS OF FOODS** written over forty years ago by a man named Brown Landone (no relation) it was pointed out that every food has a charge of electricity that can be utilized by the body. Olive oil has more electrical energy than any other food known to man — so much so that if you vaporize it the stuff will explode on contact with a spark. Olive oil is also extremely high in mineral content and I suspect that what rubbing this stuff on the feet does is send minerals and electrical current into the body. And if you don't think your feet can absorb nutrients, try this experiment: put a piece of garlic in your sock, put the sock on your foot with the garlic underneath the foot, and put your shoes and socks on. Then go to work and walk around, see if even your best friends won't tell you: fifteen minutes and they'll smell garlic on your breath.

Basically, the same thing happened with Zone Therapy that happened with the foot-washing and the olive-oil anointing: it sort of just slid out of use. Including among those of us who should know better. When there is no one versed in the same field of knowledge handy, that knowledge tends to fall into a state of disrepair. My own case is a perfect example.

The body, according to the theories of zone therapy, is divided into ten "zones" or meridians. The first zone goes from the two big toes up the inside of the legs to the middle of the head, the second zone goes from the two toes next to the big ones to areas a little from the center of the head, and so on. Actually there are two sets of five zones; equalling ten; five zones on each side of the body.

For years I've had a problem with the muscles of my lower right back tightening up. There were only two ways for me to get relief from the problem. One was to go to a chiropractor. The other was to get out and run five or more miles and loosen the muscles up that way. The first was a nuisance and the second too time-consuming. Enter Zone Therapy.

The nerves in the big toe run right through the muscles of the lower back. The nerves in the right big toe run right through the right lower back. Therefore, a lot of my problem is relievable by vigorous massage of the underneath of the right big toe. There are a couple of scientific theories that tend to support this.

One is that crystalline deposits form at the nerve endings. These keep the electrical contact or impulse of the nerves from grounding. You are merely rubbing out these crystalline deposits and thus enabling the nerves to ground in the feet, hands or wherever you may choose to work.

The other, which overlaps the first, is that somehow the proper electrical current is sent back up into the body by this manipulation which in turn puts everything back where it is supposed to be. Lakhovsky pointed out over half a century ago that every cell in the human body has a spiral helix or "coil" that is receptive to one frequency of radio waves or electrical energy. Running that current through even a cancerous cell will tend to restore it to normal. Lakhovsky built a device he

called a Multiple Wave Oscillator for this purpose that actually did cure cancer in a number of people but for now let's stick with the human thumb; the FDA hasn't outlawed its use yet.

Fortunately, there is one facet of Zone Therapy that the Medical Profession and Big Brother will never be able to squash: the fact that some of it is instinctual. When you bump your shin against a solid object the pain causes you to squeeze the injured shin — which helps block the nerve paths to the brain. The same thing occurs if you go to a dentist who doesn't use novocaine (when I was a kid mine didn't, aaaargh) and you wind up grasping the arms of the dentist chair in what amounted to a death-grip. Ironically, if the arms of the dentist chair had rough surfaces and you would spend about four or five minutes in the "death-grip" BEFORE the dentist attacked you it's unlikely you would NEED pain-deadening drugs. In many cases water will do the same thing (if injected) as a drug since all it has to do is block the nerve trunk to stop the pain.

THE SECRET OF TREMENDOUS VITALITY

By Mike Brown

A lot of times a man's occupation can be discerned by his physical appearance. The ram-rod stiff back and erect carriage of the military man is immediately evident—even an old soldier of sixty or seventy has the posture. In our highly technological society, where one's daily bread is more often determined by paper shuffling or some other sort of drudgery, where physical prowess is seldom used, the sedentary physiques of the office worker and assemblyline drone are readily identifiable.

The office worker and the drone develop their physiques (or the lack of them) from sitting or working in confined positions. Confining the lungs and rib cage by bending over a desk or assembly line results in large parts of the lungs remaining inactive. The percentage of people who know how to breathe properly and take care of their internal organs in civilized society is quite small, and the percentage of factory and office workers who do so is almost non-existent.

Our sedentary hero starts off in his early twenties hunched over a desk or workbench, rounding his shoulders and narrowing his chest. From his lack of exercise the chest muscles begin to relax their contractile strength, letting the vital organs (lungs, heart, liver, etc.) down upon the stomach and intestines. By his

early thirties the deterioration of the internal organs and further weakening of the supporting muscles cause the head to pitch forward slightly. In the early forties the knees begin to bend a little. The bending of the knees becomes more pronounced into the fifties and sixties—and what the individual winds up with is what is known as old age stoop. The doddering, shuffling, cane supported walk of the aged that is so common a sight in our society.

Contrast the foregoing description with the ones from centuries ago a barrel-chested pirate with a wooden leg, a hook for one arm, and an eye patch—courtesy of a cannon ball under the knee in the early twenties, a saber or cutlass amputation of the hand in the early thirties, and the removal of an eye by a pistol ball in the early forties. Even with an assortment of such injuries and missing appendages the average 17th century pirate was a far more effective, dangerous, and healthy individual than the office worker of today.

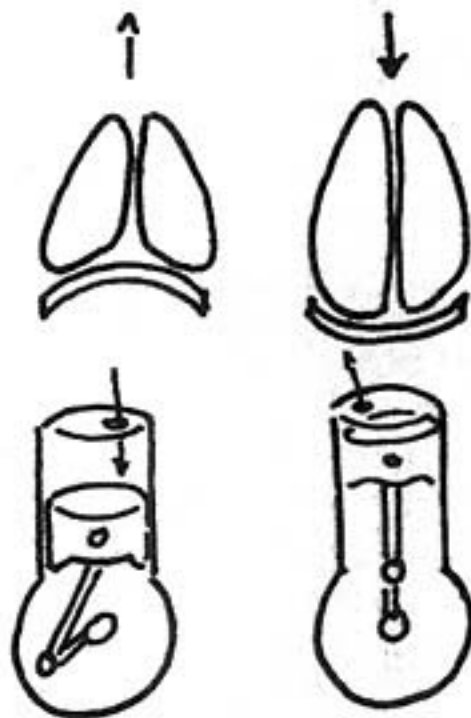
Why? What makes the difference? Why is it that some men can function effectively and are still vigorous with half their bodies shot away and others faint at the sight of blood or collapse from trifling wounds?

Basically, it's because the vitality of an

organism (including men) stems from the condition of the inner organs, especially the lungs. The "will to win" originates as much in the chest cavity as it does in the mind. The huge chest and the "heart of a lion" go together not because the fiction writers say so, but because there are sound physiological reasons for it.

To understand why this is so it is first necessary to know how the lungs work. They do not work by themselves; their actions are determined by a muscle called the diaphragm and a series of muscles called the intercostals. The function of those muscles is to create a vacuum into which the air rushes, extract the oxygen, and then push the stale air back out. Let's use a crude analogy that might make it easier to understand. The diaphragm renders much the same service to the lungs that the piston does to the cylinder in an internal combustion engine—as the piston (or diaphragm) goes down fuel (or air) is sucked into the cylinder (or lungs) because of the vacuum created. After compression and ignition (in the lungs, utilization) the piston (or diaphragm) pushes the burned fuel (or air) out of the cylinder, and the process starts all over again. The diaphragm and lungs are illustrated along with the piston and cylinder. It is important to keep this analogy in mind while doing the key exercise or you will wind up piling weight on just because you can and defeat the purpose.

Here the similarity ends. Our bodies use oxygen to burn up waste matter in the

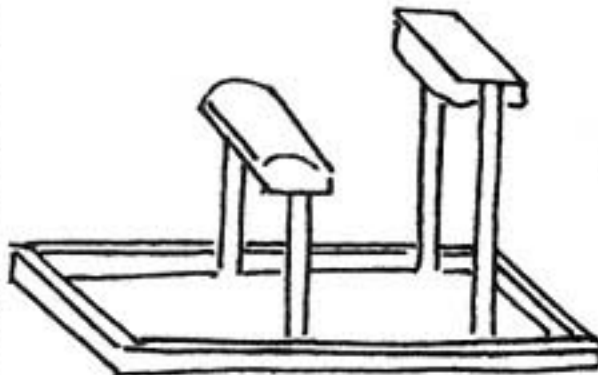


system. When the oxygen is used up the blood brings all the nasties back to the lungs they then act as a blood-cleanser and reroute the blood while exhaling the waste products and inhaling more oxygen. Unless the trash in the bloodstream is constantly disposed of the sewer then created "backs-up," the organism loses the ability to function within minutes, and dies. Theoretically, suspended animation could overcome this by halting all body processes in midstream. Headaches are quite often caused by trash accumulating in the small capillaries of the brain thereby blocking the passage of oxygen and are usually a warning to get more fresh air, burn up more of the food you're eating, or to eat less. On the other hand, the feeling of euphoria or second wind that trained athletes experience on occasion is the result of cleansing the bloodstream through constant and steady exercise. You won't get the feeling with weights unless you do very high repetitions but it occurs quite frequently with running—just a couple weeks ago I experienced it after 4½ miles of running and felt like I could have gone another 4½ with no effort at all. More than likely that was when my body had sweated off the accumulated poisons (it is possible to be completely free of body odor if the diet is pure and there are little or no poisons to be sweated off; folks who eat lots of greasy fried foods almost always stink) and my lungs had expelled most of the trash—leaving my bloodstream crystal clear. The feeling has to be experienced to be believed; it's sort of a natural high. Granted, 4½ miles hardly falls into the trained athlete class but I'm 35 years old and weigh almost 230 lbs.

It's a little difficult to train yourself into but try to breathe through the nostrils unless you simply can't get enough oxygen

that way. The nostrils are to catch impurities and warm the air going to the lungs. And speaking of warming the air, the faster you breathe and the more air you inhale the higher your body temperature goes. This is a little awkward if you're trying to survive in sub-zero weather unless you wrap a muffler or woolen scarf over your mouth and nose and inhale the warm air from inside your clothes. The bit with the muffler worked a little too well for me once, after a few minutes of inhaling warm air I fell sound asleep, outside, in sub-zero weather. Which would have been peachy except I was then a pfc in the 101st Airborne Division assigned to guard an ammo dump and acquiring this little tidbit of information cost me six months at hard labor.

So how do you achieve super health and vitality? You do it by training for the benefit of your internal organs and letting the "body beautiful" and "super strength" concepts slide for awhile. One of the advantages of this concept is that once you have achieved such vitality those stronger than you have no advantage in an altercation since their strength dissipates by the second while yours remains



constant. Of course, if the other fellow is half a head taller and fifty pounds heavier we expect you to use a little common sense.

Probably the most important of the five exercises you will be doing is known as the "breathing squat". Years ago a fellow named Roger Eells from Columbus, Ohio cured himself of TB from its use; he was the originator of the exercise. Done properly, the exercise adjusts the metabolism, increases the appetite, and improves the assimilation of food.

Place the barbell bar on the shoulders loaded with a relatively light weight. Take three deep, rapid breaths. Squat. Exhale on the way up. Do this at least twenty times. Imagine yourself as the piston I described earlier and don't worry about increasing the weight; do so only when it becomes so light as to become ineffective.

While you are still huffing and puffing from the squats grab a 20 lb. weight (never more) and do twenty pullovers rapidly off a bench, concentrate on lifting the rib cage.

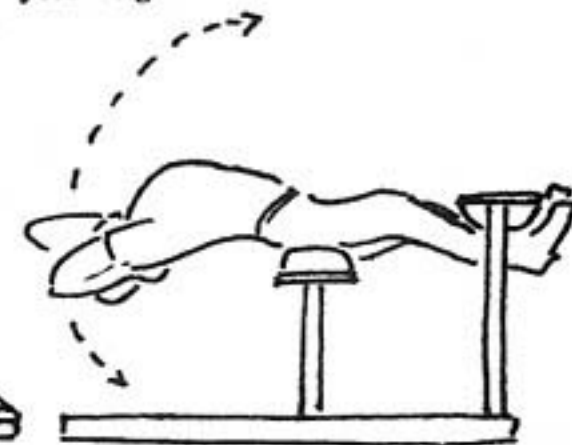
Next load the bar and do twenty bent-arm pullovers, also concentrating on the rib cage.

To protect the lower organs in the abdominal cavity do two sets of Roman Chair sit-ups (the bench and how to build it is illustrated) and finish off with a set of hyper-extensions (same bench).

The idea of the hyper-extensions are to prevent overly developed abdominal muscles from rounding the back and pulling the rib cage closer to the pelvis. The Roman Chair hyper-extension bench can be built out of either 2" x 4" lumber or angle iron.

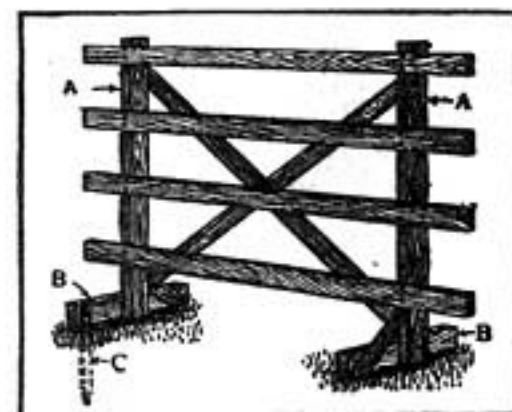
Throughout the day put a finger over one nostril, inhale, exhale through the mouth, a few times on each side. You will reach areas of the lungs high in the rib cage very seldom used.

About three months on this program and you ought to feel like you can whip your weight in wildcats.



How to Build a Grape Arbor

A grape arbor made of white pine, put together as shown in the sketch, will last for several years. The 2 by



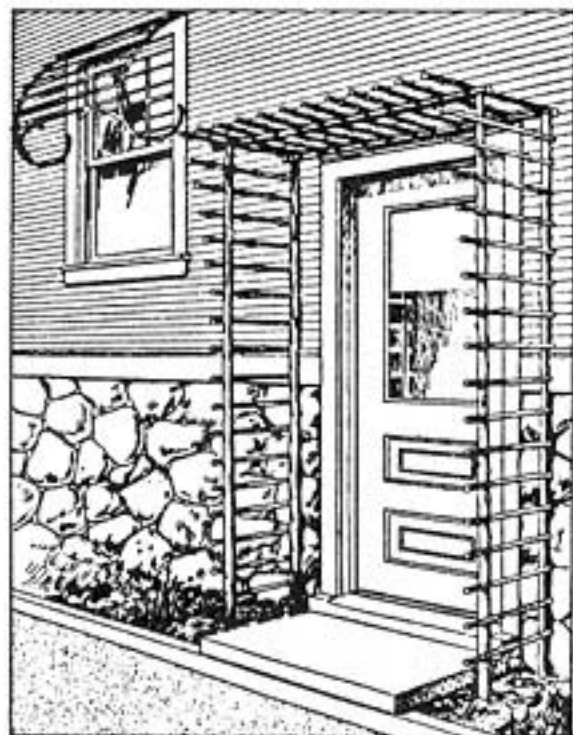
Grape-Arbor Trellis

4-in. posts, A, are 7 ft. long. The feet, B, are made 2 by 4 in., 4 ft. long, and rest on a brick placed under each end.

RUSTIC TRELLIS TO SHADE DOOR OR WINDOW

From Popular Mech. 1919

Proper preparation in the early spring will make it possible for the householder to shade doors and win-



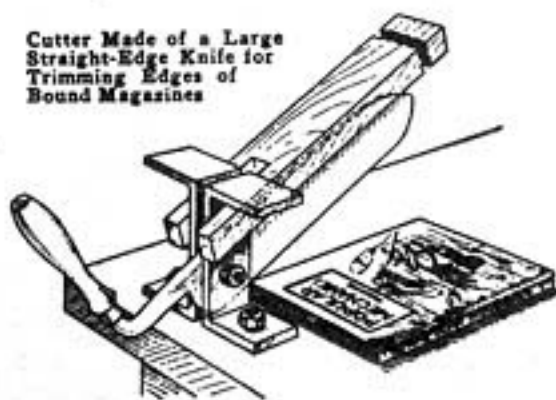
Rustic Trellises are Easily Constructed and When Covered with Vines Add to the Attractiveness of the Home

dows from the hot summer's sun by means of inexpensive rustic trellises that add not a little to the beauty of the home. A suggestion for a trellis at a doorway and one for a window are shown in the illustration. They are made of straight tree trunks and small limbs, having the bark on them. The curved portions of the window trellis may be made easily by using twigs that are somewhat green. Morning-glories, or other suitable climbing plants, may be trained over the trellises.

Knife to Trim Magazines for Binding

From Popular Mechanics 1919

There has been a number of descriptions telling how to bind magazines, but none how to trim the edges after having bound them. Desiring to have



Cutter Made of a Large Straight-Edge Knife for Trimming Edges of Bound Magazines

Emergency Sanitation at Home

The purpose of this handbook is to tell you what materials you need, and what you can do now to maintain sanitary conditions in your home or shelter if you are isolated by an enemy attack or a natural disaster.

You know that impure water and unsafe food can make you sick, or even kill you. You know that garbage and human wastes can help spread disease if not disposed of promptly. You know it is important for health reasons to keep clean, and to keep your home clean. Yet you probably take for granted the public services that now guard your family against infections of all kinds.

Many of these public services could be temporarily knocked out by enemy attack or natural disaster. If your local water utility were damaged, your household water supply would be cut off until repairs could be made. If sewer mains were broken, it would not be possible to dispose of human wastes by the usual methods until they were fixed. Lack of garbage collection and garbage disposal service would encourage the increase of rats, flies, and other disease-carrying agents. It would be hard for the people who supply you with food and fresh milk to resume their usual service for some time after disaster struck. You would be on your own until these facilities could be restored.

There are a few simple steps you can take *now* to assure your family safe water and safe food, free from harmful contamination. Also, you can be ready to handle the disposal of garbage and other wastes if you take a few prior precautions.

YOU MUST HAVE SAFE DRINKING WATER

You and your family could get along for quite awhile without food, if necessary, but you must have safe water to drink.

Interruption of this vital service, as a result of major disaster, is not the only thing that could happen to your home water supply. Leaking sewage, poisonous chemicals, radioactive materials, or even disease-carrying organisms from biological warfare attacks might get into the pipes and make your drinking water unsafe. If household pipes were broken you would want to shut off the water yourself, to avoid flooding your shelter. Or, local authorities might ask you to shut off the water supply to your home to maintain fire-fighting pressures in some other part of the city.

To insure a safe supply for emergency use, store enough drinking water for your family right now. You should have available at least seven gallons of water or other fluids for each member of your family.

This may sound like a lot of fluid to store, but the chances are that you usually have on hand several quarts of various liquids that can be used for drinking purposes. Milk serves as a substitute for water when your family is thirsty. So do all other bottled beverages such as soft drinks, fruit drinks, and liquids from water-packed fruits and vegetables. There are many emergency sources of drinking water in your home that you can use if you must, as you will read later on in these pages. To be on the safe side, however, you should store some water for drinking purposes only.

Glass jugs with tight-fitting covers or stoppers make good storage containers, provided they have been washed clean with soap and water and rinsed thoroughly. Fruit jars, quart bottles, or other types of glass containers will do just as well. Metal containers are all right but some tend to give water an unpleasant taste. It is not necessary to boil drinking water before sealing it for storage. Water fresh from the tap is safe provided the containers are clean.

STORE DRINKING WATER CAREFULLY

It is a good idea to pack your containers tightly against damage from blast or shock, especially if you are using glass bottles, jugs, or jars. You can do this by wadding newspapers, excelsior, or other packing material between the jars to keep them from coming in contact with one another. Pack them as though for a long move. Then your containers will be less likely to break if there is an explosion near your home.

Drinking water may develop undesirable tastes and odors during storage. Since waters throughout the country vary in quality, the periods of time in which these distasteful properties may develop also vary. Therefore, as a general rule,

my home-bound volumes appear as well as the other books, I made a trimmer as follows:

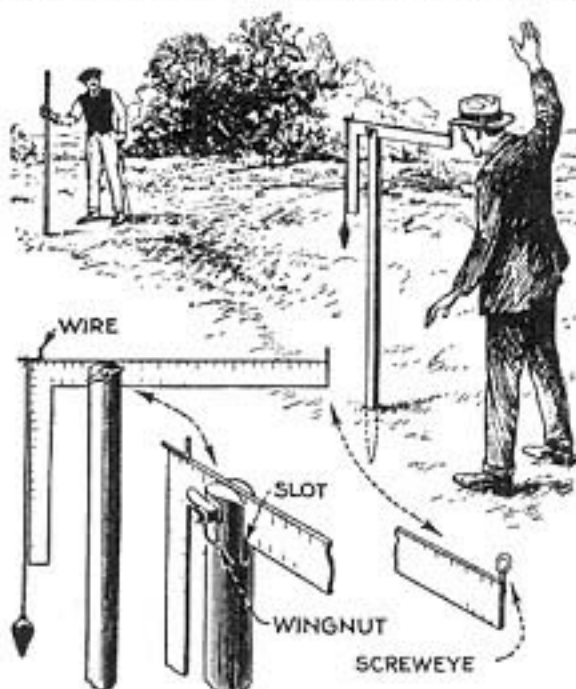
Any large knife with a straight edge will do for the cutter. I used a large hay knife. A $\frac{3}{8}$ -in. hole was drilled in the untempered portion near the back of the handle end. Two U-shaped supports were made of metal and fastened to the top of an old table, between which the knife was fastened with a bolt. A piece of timber, 6 ft. long, 4 in. wide, and 2 in. thick, was used as a lever. One end of this piece had a U-shaped notch cut in it to straddle the supports under the projecting ends. A board was attached to the table top, having one straight edge set where the knife edge would just pass it.

If the knife has a good sharp edge it will do very satisfactory work. When the edges are trimmed the knife can be removed and used for its original work.—

Improvised Level for Farm Use

From Popular Mechanics 1927

In laying out portions of the farm, sighting for building foundations, laying



Improvised Level Made from a Carpenter's Square Proves Satisfactory for Farm Use

drain tile, etc., a surveying level is useful. An improvised one, which is easily and cheaply made from a carpenter's square, is shown in the illustration. Drill a hole in the long leg of the square, 5 or 6 in. from the corner. Choose a stake, about 6 ft. long, and saw a slot down in the center at the top and bolt the square in it as shown, using a wingnut to make it adjustable and providing some washers to take the wear. A short length of steel wire, bent at right angles, is soldered to the corner of the square so that one leg points vertically about 1 in. and the other extends horizontally the same distance. A

the stored drinking water supply should be changed every 3 months, particularly if, on the basis of experience, undesirable tastes, odors, or appearances have developed.

EMERGENCY SOURCES OF LIQUIDS

Water-packed fruit and vegetables are a good source of liquids for drinking purposes in an emergency, provided the containers are undamaged. Fresh fruits that have been under cover, especially citrus fruits, are also good sources of liquids. If they have been exposed to radioactive dust or mist, however, oranges should be wiped clean before being squeezed. Other fruits such as apples or peaches should be peeled before being eaten.

Another source of good drinking water would be your refrigerator. Unless the refrigerator itself were damaged by blast, it would protect the contents against radioactive dust or mist. Even if the electricity or gas by which it operates were shut off, you could drink the water from the melted ice cubes in the trays. All other liquids stored in the refrigerator would be suitable for drinking purposes, provided they had not had time to spoil.

The water in the storage tank of your hot water heater can be used for drinking purposes if you run short. Home hot water heaters usually have a capacity of 30 or 60 gallons. Keep the hot water tank free from rust and sediment by opening the drain valve at the bottom of the tank at least once every month until the water runs clean. That is a good thing to do even in peacetime. It also assures you an extra supply of water for washing and cooking purposes in an emergency. When not under pressure (i. e., when house main valve is closed) all hot water tanks require venting to the atmosphere before a free flow of water can be obtained from the drain cock. Some are harder to vent than others, depending on the piping arrangement. Most require only the opening of a faucet on the hot water line; others may require disconnecting the hot water line from the tank at the coupling usually located at the top of the tank. Know your system and its requirements for obtaining water from the tank. Where necessary, have proper tools (pipe wrenches, etc.) handy to accomplish this.

DON'T WAIT TO STORE WATER SUPPLIES

Water to be stored should be drawn into containers *before* it is needed. Don't wait until an emergency happens before laying in your household supply. When an attack occurs, it may be too late to act. The public water service may already be interrupted or contaminated. Also, if thousands of householders tried to fill water containers at the same time, they would reduce the pressure in the street mains. That would make fire fighting more difficult. Waiting until something happens before you draw and store the water you need could cost you your home, or even your life.

HOW YOU SHUT OFF THE WATER SERVICE VALVE IN YOUR HOME

The water service valve usually is located in the basement or just outside the house, often near an outside faucet. Or, it may be found in a curb box. You should know where to find the shutoff valve that controls the water service to your home, and all members of your family should be acquainted with its location as well. Try the valve to make sure that it works freely. If a tool, such as a wrench, is needed to operate the valve, be sure you know where to lay your hands on it quickly in an emergency. And be sure you know how to use it.

HOW TO PURIFY YOUR DRINKING WATER

If you do not have enough stored water on hand in your home following a disaster, you will need to know where to get more from outside. Also you will want to know how to treat the water to make it safe. Do not use water direct from a tap immediately after an attack. If the system is still working, or as service is restored, you will be notified when it will be safe to use water drawn from the tap. Follow the instructions of the authorities. In other cases emergency water rations may be delivered to distribution points in your neighborhood. Or, you may be instructed to use water drawn from taps or wells after you have taken certain steps to purify it. Good methods of purifying water include the following:

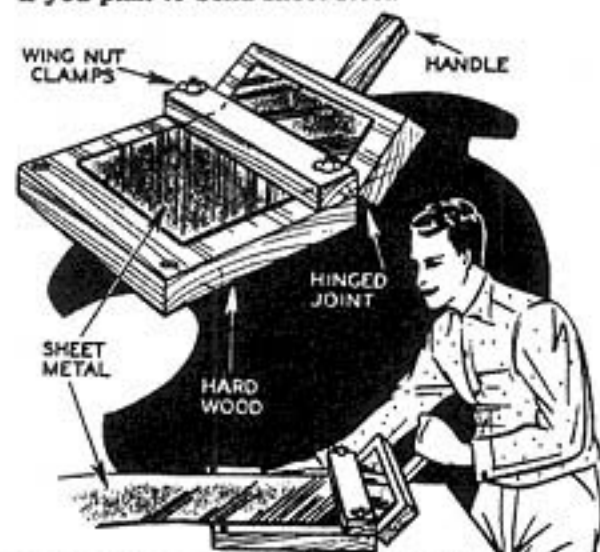
(a) *Boiling*.—Most water can be purified for drinking purposes by boiling for 5 or 10 minutes. This will destroy the germs. If desired, to improve the taste of

small screw eye is soldered to the front end of the square so that its center will be at the same height as the end of the vertical wire at the corner. Hang a plumb bob from the horizontal wire as indicated and arrange the cord just clear of the vertical edge of the square. To use the level, push the stake vertically into the ground and point the level toward the target, which is held by an assistant. Set the square in such a position by means of the wingnut that the cord holding the plumb bob will hang parallel to the vertical side of the square, which makes the horizontal side perfectly level. The target is raised so that it can be seen by sighting through the screw eye in line with the vertical wire, like sighting a gun. A straight line from the horizontal edge of the level to the point sighted on the target will then also be perfectly level.

Jig Bends Sheet Metal Accurately

Modern Mechanics 1935

WITH this easily built jig, sheet metal for radio cabinets may be quickly and evenly bent to any desired angle up to 90 degrees. Two boards are hinged together, with a wood clamp to hold the metal in position while one of the hinged portions is being raised. Use hardwood throughout especially if you plan to bend sheet steel.

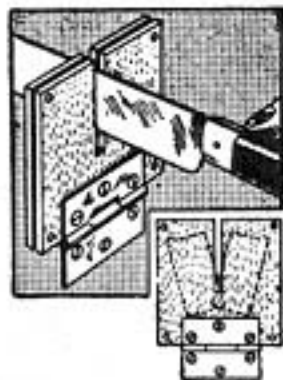


Metal panels are neatly and quickly bent with this simple jig.

A Table-Knife Sharpener

From Popular Mechanix 1919

The knife sharpener shown can be easily made of two pieces of thin wood, such as cigar-box covers, about 2 in. wide and 2½ in. long, and two discarded safety-razor blades of the heavier type. Lay the wood pieces together and saw a slot down the center for about 1¾ in. Lay the two



the water after boiling, simply pour the boiled water, after it has cooled, from one container to another several times.

(b) *Chlorination*.—It may not be possible to boil your drinking water due to the failure of gas or electric power, or damage to your stove. Open flames are a good thing to avoid in the first few hours following an enemy attack, due to the danger of fire from gas or fuel oil leaks in your home or neighborhood. Under these conditions it would be better to chlorinate your drinking water instead of boiling it.

Any household bleach solution available in grocery stores that contains hypochlorite, a chlorine compound, may be used for this purpose. Bleach solutions having 5.25% sodium hypochlorite by weight, as the active ingredient, are most commonly available. You can add the disinfectant solution to the water in any clean container in which it can be thoroughly mixed by stirring or shaking. The proper amounts to be used can be estimated from the table

Dosage¹ of Chlorine Solution for Disinfecting Drinking Water

Gallons of water	Dosage of 5.25% solution for—	
	Clear water	Cloudy water
¼ (one quart).....	1 drop.....	3 drops.
1	4 drops.....	10 drops.
5	¼ teaspoon.....	½ teaspoon.

¹ For different chlorine strengths and for other volumes of water, the dosage should be adjusted proportionally. After adding the proper dosage and stirring, allow the water to stand for 30 minutes. After that length of time it should have a distinct taste or smell of chlorine. If this taste or smell is not present, add another dose to the solution and

SOURCES OF LIQUIDS

Your stored water supply
and bottled drinks

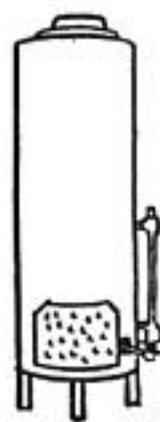


Water-packed fruits
and vegetables



Fresh fruits

Ice cubes and liquids stored
in undamaged refrigerator



Water from hot water
heater, if clean

let the water stand for another 15 minutes. The taste or smell of chlorine in water thus treated is a sign of safety. It is not harmful. On the contrary, if you cannot detect chlorine in water that you are trying to purify by this method, do not drink it. The solution may have become weak through age or for other reasons.

(c) *Purification tablets*.—Tablets which release iodine may be used safely to purify drinking water. These are not generally available in commercial retail stocks,

razor blades at an angle of about 2° on each side of the slot, as shown, fasten them to one of the boards, and securely attach the other board over them.

To sharpen a knife, run it through the slot two or three times. The sharpener can be fastened with a hinge so that it will swing inside of the drawer, or box, that the knives are kept in, and it will always be ready for use.

Homemade Graining Tools

From Popular Mechanix 1915

Desiring to do some fancy graining and having no tools at hand, I hastily made two of them from pieces of gar-



Tools Cut from Pieces of Garden Hose for Making Grains of Wood in Painted Surfaces

den hose, as shown in the sketch. Two pieces were cut from the hose, each 5 in. long, and the first one made as follows: A small hole, about $\frac{1}{4}$ in. in diameter, was cut through the outside layer of rubber with a sharp knife at two points on opposite sides of the hose and exactly in the center for length. Around these holes rings of the rubber were cut out, or rather peeled off from the canvas part, the rings being $\frac{3}{8}$ in. wide, and the grooves, or parts removed, also $\frac{3}{8}$ in. wide. The hose will then appear as shown in the upper left-hand corner of the sketch.

To use this grainer, first paint the ground color, using a buff tint for imitation light oak, and allow it to dry, then put on a light coat of raw sienna, and while wet, take the prepared hose and draw it slowly over the length of wood, at the same time revolving the grainer slowly.

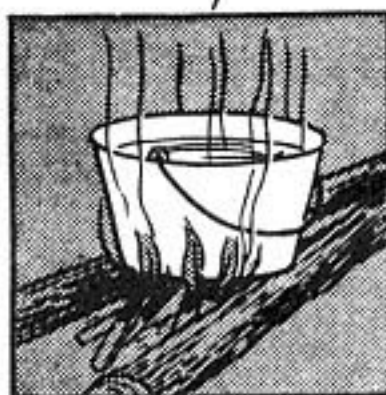
The other piece of hose, at the other corner, is made to take the place of a steel graining comb. The rubber is cut away lengthwise, leaving four segments, about 4 in. wide, on four sides of the hose. These segments are then notched out, like threads on a tap, each

at present, but may occasionally be found at drug and sporting-goods stores. Use tablets in accordance with instructions on the package. Usually one tablet is sufficient for one quart of water; the dosage is doubled with cloudy water.

(d) *Iodine*.—Ordinary household iodine may be used to purify small quantities of water. Add 2 or 3 drops of tincture of iodine or iodine solution to each quart of clear water (8 to 10 drops for cloudy water). Mix and allow to stand for 30 minutes.

(e) Other methods of purification may be recommended by the proper authorities if special conditions arise. In such cases follow the instructions of your local government officials.

FOUR METHODS OF WATER PURIFICATION



Boiling
5 to 10 minutes



Iodine
2-3 drops per quart
of clear water



Purification tablets
Use manufacturer's
directions



Chlorination
See TABLE for directions

SPECIAL TIPS ABOUT WATER USAGE

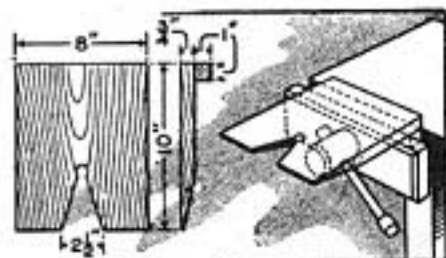
If you are asked to shut off the service valve that controls the water supply to your home, or if the taps do not flow following a disaster, turn off all the water outlets. These include taps or faucets, valves on pipes supplying float-controlled equipment such as flush toilets, air-cooling equipment, and heating equipment. Then, when

segment having a different number to the inch. These are used in the same manner as steel combs.

Jig-Saw Table for Vise

From Popular Mechanix 1919

Those who have occasional work to be done with a jig saw will find the simple device shown in the sketch convenient. It provides a table for sawing light work. By holding it in a vise, as shown, a rigid support may be had. The table is made of a rectangular piece of $\frac{3}{4}$ -in. wood, 8 in. wide and 10 in. long. At one end, a strip, 1 in.



The Jig-Saw Table Provides a Rigid Support for Light Fretwork

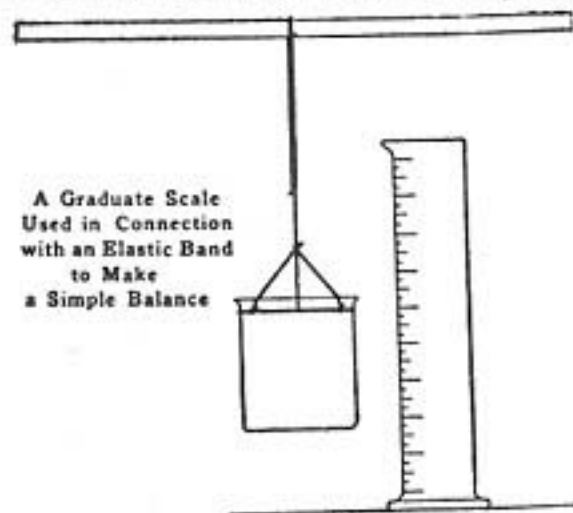
square, is attached for clamping in the vise. The other end is notched to provide a place for the saw while in use.

A Simple Balance

From Popular Mech. 1919

Having use for a balance in a laboratory and being unable to procure any scales at the time, I hastily rigged up a device that served the purpose as well, as the work did not require very great precision. An elastic band and a short piece of string was procured and the band cut open. The string was then fastened around the beaker as shown, and the whole suspended from a shelf.

Into the beaker was then poured 100 cubic centimeters of water and the stretch of the elastic band noted by the



A Graduate Scale Used in Connection with an Elastic Band to Make a Simple Balance

displacement of a knot in the string in

the water comes on again your home will not suffer flooding.

Turn off the gas or electricity that supplies your hot-water heater after closing your home water service valve, or when your water supply is interrupted for any other reason. Otherwise, if the limited supply of water remaining in your hot-water storage tank continues to be heated, an explosion may occur. Also, if no more water can reach the tank, continued heat will soon muddy its contents and make the water useless for washing or drinking purposes.

If your water service is cut off following enemy attack, do not try to telephone or otherwise communicate with your local water department or water company. The officials in charge will be doing all they can to restore your service. Complaints will only add to their burdens. Besides, you will be using telephone lines that are needed for other emergencies.

Once service is restored, the water from your faucets may have a strong chlorine taste. Do not worry about this. It is a sign that extra precautions are being taken for your safety. If there is any doubt about leaks in the water mains or other possible sources of contamination, more chlorine than usual will be added to the water supply by health officials to make sure that it is safe.

Do not drink or use for cooking purposes any water other than that obtained from your faucet, or other recommended emergency source in the home, or from special water dispensing stations operated by proper authorities. It is dangerous to use water that has not been properly purified or approved. This applies to all other sources that have not been inspected, such as wells, cisterns, streams, or ponds. If the public water supply service cannot be restored within a reasonable time following disaster, emergency water rations will be made available to you. Meanwhile, play it safe.

Be alert for instructions regarding water usage from your public health officials, or from the water department itself. These are the proper authorities to advise you about the safety of your water supplies. Their instructions will be relayed to you by messengers, radio, mobile loudspeakers, handbills, or newspaper stories. Don't listen to any rumors from other sources about the safety of your water supply, or pass on rumors to others. Pay attention to official instructions only.

BEFORE DISASTER STRIKES YOU SHOULD KNOW....



Where to find safe water



How to turn off water service valve



How to purify water



What foods to store and how to prepare them



How to dispose of garbage



How to dispose of human wastes



How to make soil bags



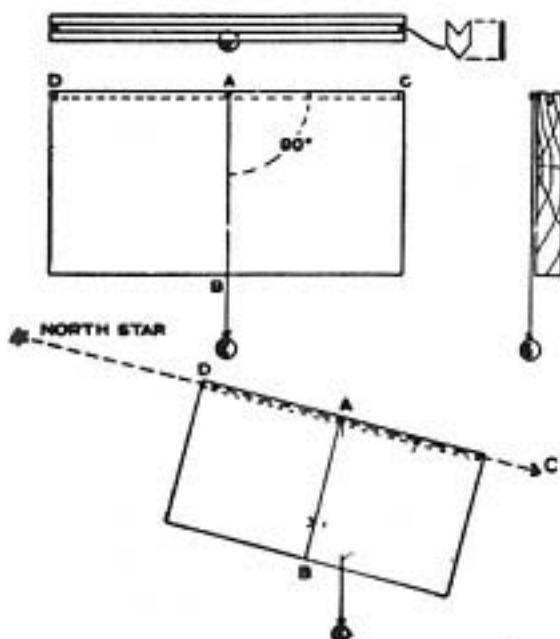
What to do with frozen foods

respect to the scale on a graduate, placed beside the beaker. The length of the elastic was then changed until the knot was exactly opposite the 100-division mark on the graduate scale. Then, since the elongation of the elastic band follows Hook's law, the extension of the band to the amount of one scale division means an added weight of one gram in the beaker.—

A SIMPLE SEXTANT

From Popular Mechanics 1915

A sextant for measuring the latitude of any place can be easily constructed as follows: While a board, 1 in. thick, 8 in. wide, and 12 in. long is about right for the instrument, any dimensions can be used, providing the line AB is at perfect right angles to the level of the sights C and D. The sights are better to use, although the upper edge of the board, if it is perfectly straight, will do as well. If it is desired to use sights, a slight groove is cut in the upper edge; a V-shaped piece, cut from tin, is fastened at one end, and a small pointed nail is driven in at the other. In doing this, be sure to level the bottom of the V-notch and nail point so that in drawing the line AB it will be at perfect right angles to a line between the sights. A tack is driven into the side of the board at the upper edge, a line fastened to it and a weight tied



The Main Part of the Instrument Consists of a Board with a Plumb Attached

to the lower end which should swing below the lower edge of the board.

The instrument is placed in such a manner that the North Star is sighted, as shown, and the point on the lower edge of the board is marked where the line E comes to rest. A line is then drawn from A to the point marked and the angle F is measured with a protractor. The number of degrees in this

YOU MUST HAVE SAFE FOOD

After an attack the contents of cans, jars, cartons, and other food packages that have not been broken or punctured by a nuclear bomb blast would be perfectly safe to eat. Most radiation that is destructive to living tissue is not damaging to most other materials, including packaged food.

However, it would be well to wipe or wash carefully any can, bottle, or other containers—or any covered dish—that had been exposed to radioactive mist or dust. Tiny particles of "bomb ash" often are to be found in such mists and dusts. These particles are still radioactive and can make you sick if enough of them get inside your body. Radioactive dust on cooking or eating utensils is another problem. Such dust cannot be made harmless by boiling. The particles can be washed or wiped away, but that does not render them harmless. They are still "hot" and will remain on the cleaning cloth or in the wash water.

After an attack, you should not drink water that has been exposed to the open air until local officials announce that it is safe. Water from closed containers will be all right. Water stored in open tubs or buckets may not be. The same thing applies to food that may have been left out in the open. Food that has been stored in closed cupboards or in your refrigerator should be safe to eat after an attack. Food that has had no protection may not be.

INCREASE HOME FOOD STOCKS

After a thermonuclear attack, a most difficult task of survivors will be that of obtaining food and water without overexposing themselves to fallout radiation. This fact emphasizes the importance of keeping on hand at least a 2-week supply of food and water. This supply can mean the difference between life and death.

During emergencies, stored food and water should be used conservatively to prevent wasting them or exhausting them too rapidly. If refrigerators or deep-freeze units become inoperable, the food in them should be used first. By opening them only once daily, you can keep remaining food in them from spoiling for a reasonable time.

If you do not already keep a 2-week food supply in your home, increase it accordingly at once. Maintain it continuously by one of the following methods:

(a) *Increase current food stock.*—This method merely means that you keep a 2-week supply of food on hand. It is no different from the food that you normally use in preparing your daily meals. You just make sure that there is always sufficient food to last for 2 weeks by replacing the food as you use it.

(b) *Shelter reserve food supply.*—This method means that you always keep a 2-week supply of selected food stored in your family shelter. For a shelter reserve food supply, select foods that store easily, keep for months without refrigeration, are easily prepared, and require little or no cooking.

Foods canned in metal and glass will stay in good condition for 6 or more months if kept in a dry place, protected from sun and dust, and kept at a fairly cool temperature—preferably not above 70° F., or below freezing. To keep food in paper boxes as long as 6 months, place them in tightly closed metal cans or cabinets and store them under the dry, cool, clean conditions specified for canned foods, so that rodents and insects are not likely to attack them.

It is good practice to rotate foods in cans at least once or twice a year and foods in paper boxes (without added protection) at least every 3 months. This will insure having a reserve supply of food that is good tasting. As food on the reserve shelf is used for meals for unexpected company and the family, replace it, putting the older stocks in front of the new supply.

If required, include special milk or strained, chopped, or other special foods for infants, toddlers, older persons, diabetics, invalids, and others on a special diet.

Cans and jars in sizes which will meet family needs for only one meal are best for meat, poultry, fish, vegetables, fruit, evaporated milk, and other foods which deteriorate rapidly, unless refrigerated, after the container is opened. This also helps to eliminate the problem of leftovers.



What foods are unsafe

angle will be approximately equal to



The Two Stars at the End of the Great Dipper are Pointers to the North Star

the number of degrees in the latitude of that place.

The North Star is easily located by reason of its position relative to the Great Dipper, as shown by the diagram.

Utilisation of Chicken Feathers.

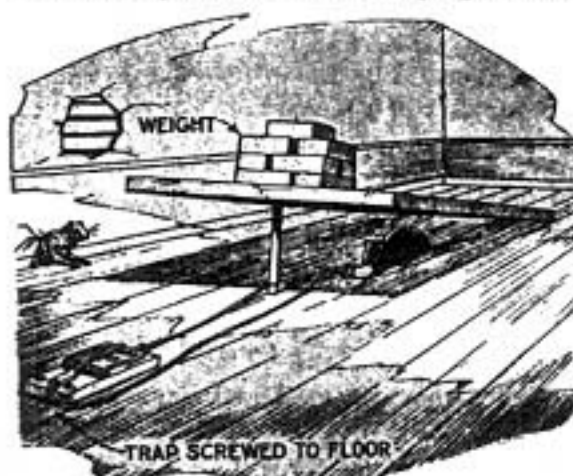
Cut the plume portions of the feathers from the stem. The former are then placed in quantities in a coarse bag, which, when quite full, is closed and subjected to a thorough kneading with the hands. At the end of five minutes the feathers become disaggregated and felted together, forming a down perfectly homogeneous and of great lightness. It is even lighter than natural eider down, because the latter contains the ribs of the feathers, which give extra weight. The material thus prepared is worth and readily sells in Paris for about 20 francs (\$4.00) a kilogramme (2.2 pounds). About 1½ ounces of this down can be obtained from an ordinary-sized chicken. Through the winter children can collect all the feathers about a farm and cut the ribs out as has been stated. By spring time a large quantity of down could be prepared, which could be sold to upholsterers or employed for domestic uses. Goose and turkey feathers may be treated and utilized in the same manner.

The chicken down forms a beautiful cloth when woven. For about a square yard of the material about 1½ pounds of down are required. The fabric is said to be almost indestructible, as, in place of fraying or wearing out at folds, it seems to felt the tighter. It takes dye readily and is thoroughly water-proof.

Unusual Rat Trap

From Popular Mechanics 1928

I had considerable trouble with a rat which always succeeded in keeping out of



Novel Rat Trap Consisting of a Large Board Which Falls on the Victim

YOU SHOULD HAVE



Stored water or other liquid (7 gals. per person)



A 2-week supply of proper foods, paper plates and napkins



Cooking and eating utensils, measuring cup, can and bottle openers, pocket knife and matches



Special foods for babies and the sick



Large garbage can to keep garbage



Smaller can for human wastes



A covered pail for bathroom purposes



Toilet tissue, paper towels, sanitary napkins, disposable diapers, soap



Rubber sheeting and special equipment for the sick



Grocery bags, week's supply of newspapers for sanitary uses, waterproof gloves



2 pts. of household chlorine, 1 qt. of 5 per-cent DDT



Wrench, screwdriver, shovel, and other tools

HOW TO EAT SAFELY

All cooking and eating utensils, including tableware, should be thoroughly scrubbed with soap and water if there is any possibility that they have been exposed to radiological, chemical, or biological contamination. Packaged dishwashing powders are all right for washing such utensils. So are strong soaps. If your water supply has been cut off, wash only the utensils you need to use.

Paper cups and plates are handy things to have if the water supply is cut off, because they need not be washed and can be burned with the rubbish. Paper towels and napkins are good, too, when laundry needs cannot be met. If you have room, store a good supply for emergency use. The wrappers they come in will protect them from radioactive dust and mist unless the packages are broken.

Refrigerators and home freezer units should be kept closed as much as possible once the services they depend on are cut off. The foods they contain will keep longer if you don't open the doors any oftener than necessary. If the gas or electric service is not restored within 12 hours, eat or cook the most perishable items in your refrigerator before they spoil. If foods show signs of decomposition, throw them out before they contaminate other foods that keep better.

Food will keep in home freezer units, after they are shut off, for varying periods depending on the amount and kind of food, the temperature at which it was kept, and the construction of the freezer. Frozen meats and other frozen foods can be

the spring trap I set for it. Determined to get it, I rigged up the unusual trap shown in the drawing. It consists of an old cabinet door, about 2 ft. square; a short stick 6 in. long, a weight and a spring trap. The latter is screwed to the floor; the cabinet door is raised so that one edge rests on the stick, which is set under the door as indicated. A suitable weight is laid on the inclined door. The spring part of the trap is connected to the stick with a stout cord. Another cord is tied to the trigger at one end, and to the bait at the other, which is laid on the floor under the center part of the door. The trap is then set so that, when sprung, it jerks the stick from its position, and the door, being unsupported, falls down. When the rat takes hold of the bait, and before it has time to get away, the door falls on it. The trap caught the rat that had evaded the former trap and did great execution among the others.

Smoking Out Underground Animals

From Popular Mechanics 1925

A woodchuck or other burrowing animal cannot remain long underground if the device shown in the drawing is used.



"Smoking Out" Woodchucks, Rabbits, and Other Burrowing Animals is Greatly Simplified by Using an Apiculturist's Bee Smoker

A funnel-shaped cardboard cone, about 1 in. in diameter at the small end and large enough to cover the opening of the burrow at the other, is connected to a beekeepers' smoker by an 8 or 10-in. length of garden hose. The smoker is filled with rags and lighted, the large end of the cone being placed over the hole and a wet gunny sack packed around the cone and hole. With the rags burning and making a good smudge, the bellows of the smoker is worked, to drive the smoke down into the burrow. A little of this treatment will speedily bring any animal out of his "emergency" entrance, dazed and stifled.

A Home-Made Vise

From Popular Mechanics 1913)

Cut two pieces of wood in the shape shown in the sketch and bore a $\frac{3}{8}$ -in. hole through both of them for a common carriage bolt. Fasten one of the pieces to the edge of the bench with

preserved for later use by cooking them soon after they have thawed or by quick refreezing before they have completely thawed.⁴

Milk needs special attention when an emergency occurs because it is easily contaminated. If you are not sure your supply of fluid (bottled) milk has been pasteurized, you should heat-treat it at home before using. You need not worry about canned milk because it has been heat-treated in processing. Heat-treating gives bottled milk a cooked flavor, but it is a wise precaution to take when public sanitation services fail. Here are two simple methods for heat-treating fluid milk at home:

(a) Bring the milk quickly to a boil in an open saucepan while stirring constantly. If a good cooking thermometer is available, heat the milk to 165° F. instead of to a boil. Then place the saucepan in cold water and stir the milk until it has cooled.

(b) Pour water into the outer unit of a double boiler and bring it to a vigorous boil. Pour the milk into the inner unit and settle it in place, letting the boiling water in the outer unit heat the milk. Cover and maintain water at a boil for 10 minutes.

Produce from your home vegetable gardens may be contaminated during an enemy attack. Do not eat such produce, or even collect it, until the neighborhood has been officially declared free of contamination.

Official instructions regarding food will be issued locally in the event of an emergency. These instructions will tell you the type of disaster and its effect upon milk and other foods. Follow official instructions closely. Don't listen to rumors, and don't pass them on to others.

EMERGENCY COOKING

If public utilities are out, it may be necessary to improvise equipment for heating water or for cooking and serving meals. This will insure supplies of hot water for washing, and permit heating of foods to proper temperatures for making them safe.

There are many ways of improvising heating equipment depending on one's ingenuity and the time and material available.

Canned-heat burners usually may be used safely indoors except in shelters, where burning fuel may deplete the oxygen supply. Of course no open flame will be safe when gas, fuel oil, or explosives are nearby. Remember that fire is even more dangerous if the water supply is cut off. To use canned heat properly, first remove the paper label from around the can. Pry off the cover and touch a lighted match to the can's contents. Never blow out the flame. To extinguish it, slide

the cover on upside down. Wait for the can to cool, turn the cover right side up, and press down. Prevent canned heat from evaporating by keeping the cover on tight when not in use.

In many natural disasters, or following an enemy attack (if radioactive fallout presents no hazard) out-of-doors cooking can be done over several types of fires such as the trench fire, the hunter or trapper blaze, or an improvised fireplace. Each of these can be easily controlled and offers adequate space for pots and pans.

A trench fire is nothing more than a fire built in a trench dug in the ground—if possible, to face the wind. This assures proper draft unless too strong a breeze is blowing, in which case an open fire should not be built.

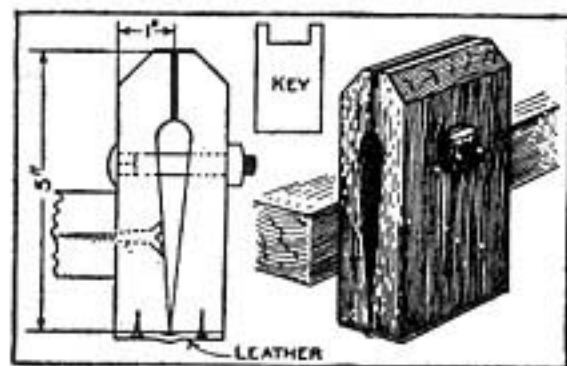
Support for the pots and pans can be made from articles such as a piece of flat scrap sheet iron or a sliding grate from a kitchen stove. Many more materials can be used as supports for pots and pans in which to cook or heat water over a trench fire.

The hunter or trapper blaze is a fire laid between two parallel green logs, flat rocks, rows of brick, or pieces of beams placed facing the wind. By varying the angle of the beams, rocks, or brick it is possible to accommodate varying sizes of pots and pans.

Another type of fire can be laid in an improvised fireplace made of bricks or rocks. The fireplace may be nothing more than a slanting hole dug into the side of a hill or in your backyard. The fireplace must have a chimney for proper draft.

Remember, a large fire is unnecessary. Fires made from such hardwoods as oak, hickory, maple, ash, or beech last longer and produce the best coal bed. The coal bed makes the difference between easy and difficult cooking. The harder the wood

a large wood screw and attach the other piece to the first one with a piece of leather nailed across the bottom of both pieces. The nut on the carriage bolt may be tightened with a wrench,



Details of a Home-Made Bench Vise

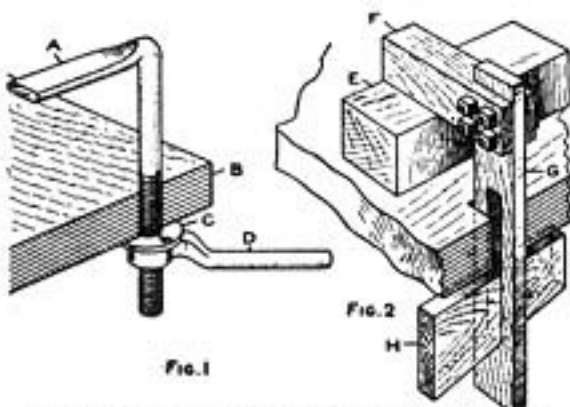
or, better still, a key filed out of a piece of soft steel to fit the nut. The edges of the jaws are faced with sheet metal which can be copper or steel suitable for the work it is intended to hold.

TWO SIMPLE VISES FOR THE HOME WORKBENCH

From Popular Mech. 1919

Boys, and other amateurs, sometimes have need of a vise when a commercial article or one of standard type cannot be had readily. The devices shown in the illustration will give good service and can be made of material easily obtained. The vise shown in Fig. 1 was made of old machine parts, consisting of a bolt and a wing nut. The bolt A was flattened at one end and bent at a right angle. A hole to fit it was bored through the top of the bench B, and the washer C and wing nut D were put in place. The piece to be gripped is clamped under the end A. This device should be fitted near the end and front edge of the bench.

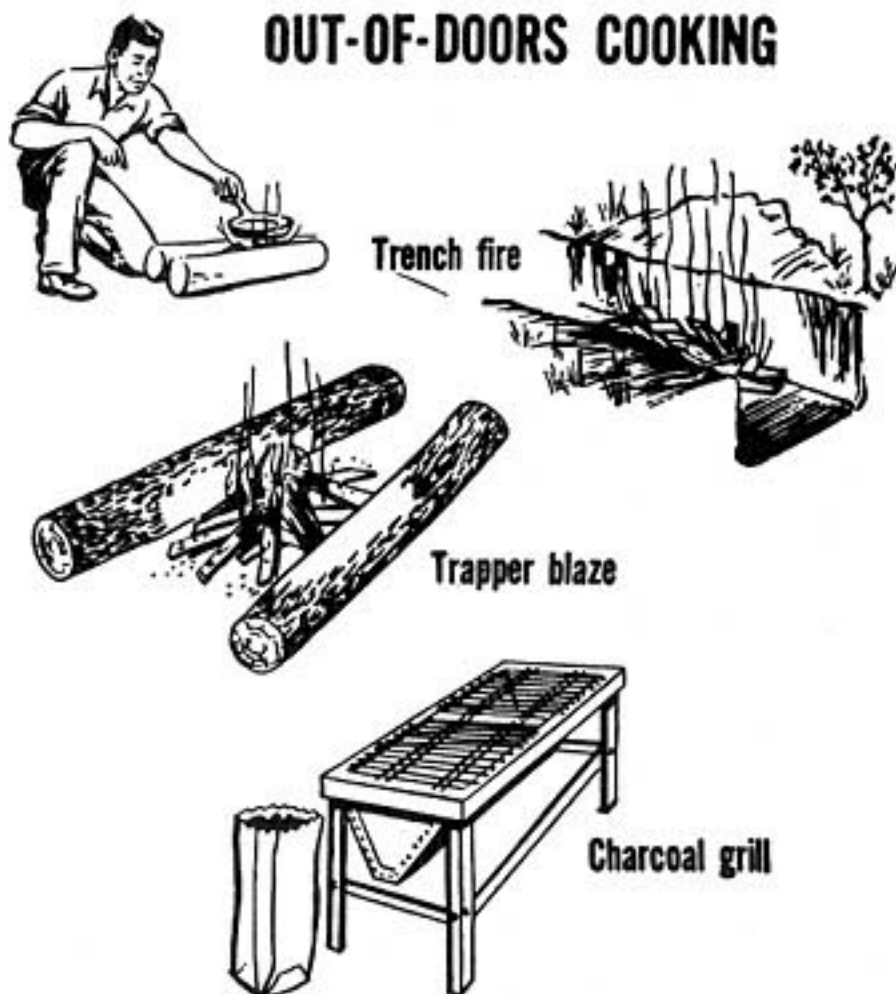
The vise shown in Fig. 2 grips the block E in the same manner as the first



These Vises may be Made Easily of Materials Available in Most Workshops

vise. The jaw F is bolted to a vertical piece, G, which is fitted into a mortise cut through the bench top. The wedge H passes through a mortise in the piece G and clamps against the lower side of the bench top.

OUT-OF-DOORS COOKING



the steadier and more even the heat.

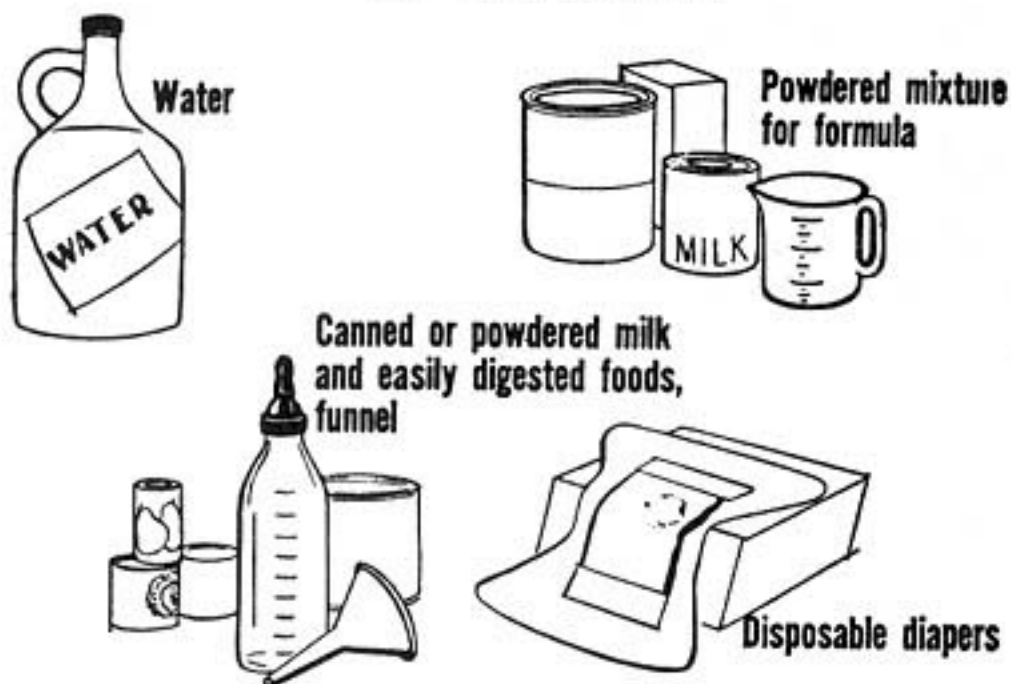
If a Dutch oven (a cast iron pot with a lid) is available it can be placed directly on the coals. The coals should be heaped high around the oven.

In addition to these other methods of improvised cooking, it is possible to use an inexpensive charcoal grill that burns briquets or wood.

Actually, one need not be an expert to know how to cook out-of-doors. A little practice, patience, and some ingenuity will produce results. When selecting an outdoor cooking site, remove all flammable materials surrounding the site, and do not select a cooking site that is near broken gas pipes.

WHAT YOU SHOULD STORE:

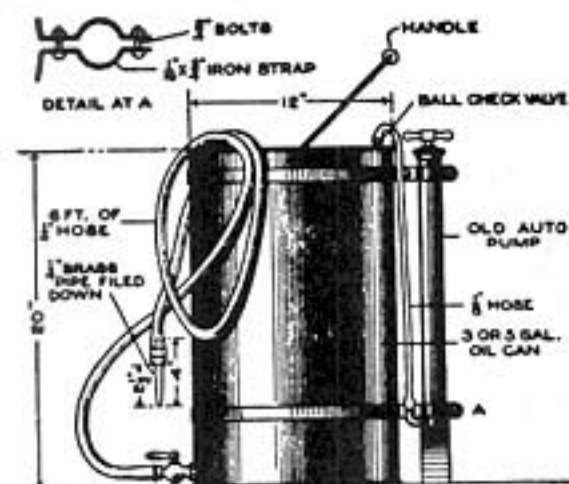
FOR YOUR BABY...



Pressure Spray Made of Old Oilcan

From Popular Mechanix 1919

In making a spraying outfit for garden use, or similar purposes, a 3 or 5-gal. kerosene can and tire pump may be

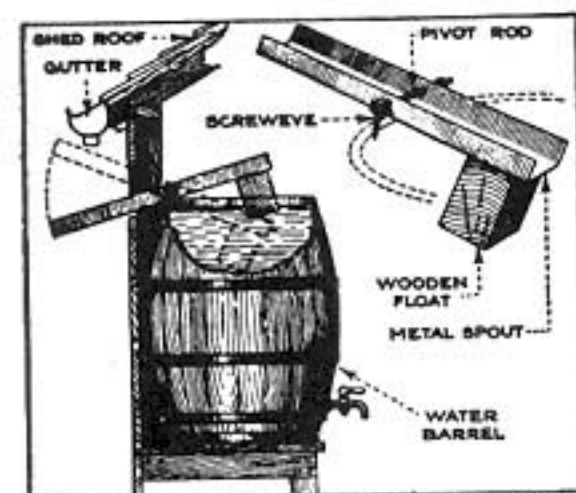


Old Material Makes a Spray That Is as Good as the Manufactured Product, at Less Cost

satisfactorily employed. The latter is attached rigidly at the rear of the container with iron straps, as shown. A ball check valve is fitted in the top of the receptacle and connection is made between it and the pump with the pump hose. A 6-ft. length of $\frac{1}{4}$ -in. rubber tubing is wired to the drain cock. An 8-in. piece of $\frac{1}{4}$ -in. brass pipe is filed down and wired in the spray end of the hose to serve as a nozzle.

Simple Water-Barrel Regulator

In order to simplify the installation of a rain barrel and do away with the inlet and overflow pipes, as well as provide an

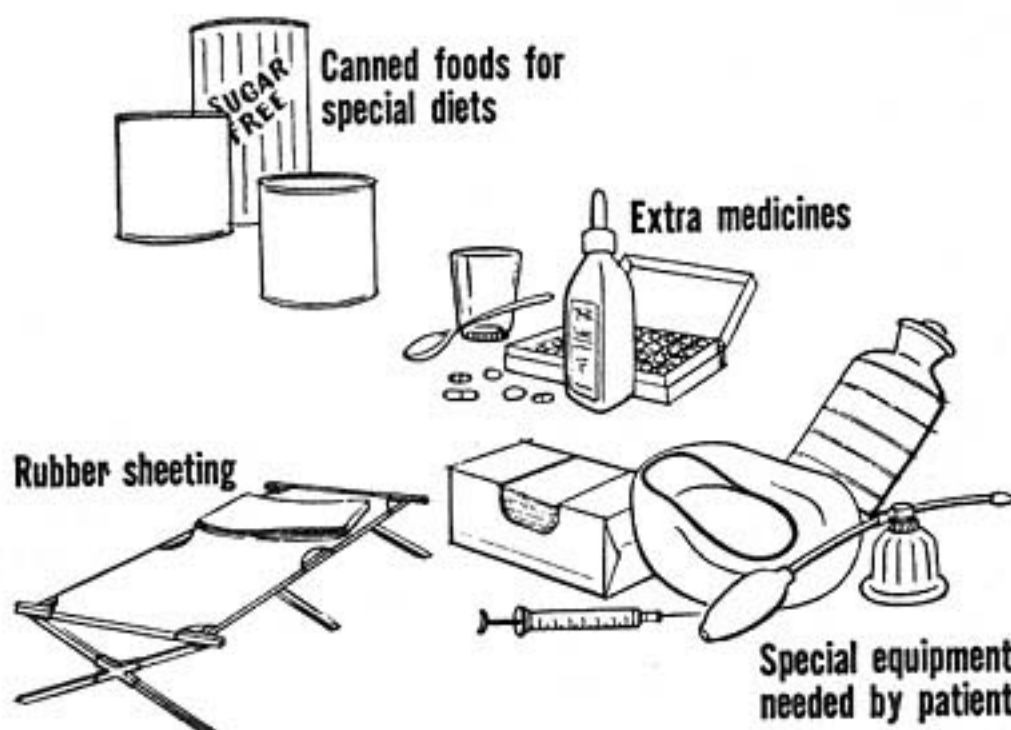


An Automatically Regulated Rain Barrel for Storing Soft Water: When the Barrel Is Full, the Auxiliary Spout Delivers the Rain Water on the Outside

automatic method for cutting off the flow when the barrel is filled, the arrangement illustrated was adopted.

A spout of sheet metal is pivoted to the edge of the barrel by means of screw-eyes and a transverse rod. The inner end of the trough is fitted, on the underside, with a wooden float so that as the barrel is filled, the float raises the spout and the water is diverted to the outside. As the water is drawn from the barrel, the outer end of the spout rises in readiness for the next rainfall.

FOR INVALIDS...



EMERGENCY SEWAGE DISPOSAL

Water flush toilets cannot be used, of course, when water service is interrupted. The water remaining in the fixture is not sufficient to flush the wastes down the sewer. Clogging may result, and your living conditions then become just that much more uncomfortable.

Even if water is available, local authorities may ask you not to use flush toilets, wash basins, and other fixtures connected with soil pipes. The sewer mains may be broken or clogged, which would make it impossible to carry off such wastes. Or water may be needed for fire fighting. It is necessary for every family to know emergency methods of waste disposal, in case such conditions arise.

Failure to properly dispose of human wastes can lead to epidemics of such diseases as typhoid, dysentery, and diarrhea. At the same time, sewage must be disposed of in ways that will prevent contamination of water supplies used for drinking, cooking, bathing, laundering, and other domestic purposes. Here are simple steps that any family can take to prevent such dangers and discomforts:

(a) Right after a disaster, or during one, you will probably not have the time and tools to prepare a complex emergency sanitation system. If there is a delay of several days in restoring sewerage service to your neighborhood, you may find that disposal is a big problem. Your first task, however, is to make some temporary toilet provision for members of your family, especially the children. Almost any covered metal container will do. You can use a covered pail. A small kitchen garbage container with a foot-operated cover can be put to toilet use in emergencies. Anything that has a cover and will hold the contents until you can dispose of them will serve for sanitary purposes, at first.

(b) Keep on the premises at least one extra 10-gallon garbage can or other waterproof container with a tightly fitted cover. This should be lined with paper, and the cover should be fastened to the can to prevent its loss. Such a can may be used for the emergency storage of body wastes until the public sewerage system can be put back into action, or until other arrangements can be made. Empty your smaller vessel into it as often as necessary. A small amount of household disinfectant should be added after each use. If you live in an apartment, you may not have a large garbage can or room to keep one. In that case two smaller covered pails or other containers will do just as well.

(c) Keep a shovel on the premises if there are unpaved yard areas nearby. Burying human waste matter under 12 to 24 inches of earth is a satisfactory method of emergency disposal. Never deposit wastes, liquid or solid, on the surface of the ground. Insects and rodents may carry infections to other humans.

(d) Where radioactive fallout does not present a hazard, a temporary pit privy may be constructed in a yard area for use by several families. This offers a good method of waste disposal over extended periods of time. The structure need not be

Inner Tube Operates Spray Gun

Modern Mechanics 1932



Inner tube inflated as large as possible to operate air brush should be connected to tank by means of rubber hose, after air valve has been removed from the tube.

NOW you can spray your furniture without the use of a big air tank. By removing the air valve from an old inner tube and connecting it to your spray gun, as illustrated above, you can do some fine jobs. Inflate tube as much as it will stand. The hose used should be strong enough to withstand the high pressure.



Contents of Mail Box Attached to Door Jamb Cannot Be Removed Unless the House Door Is Open

Theft-Proof Mail Box

From Popular Mechanics 1928

Theft of letters, etc., out of mail boxes can be prevented to a great extent by providing a box from which the contents cannot be removed unless the house door is opened, or the box destroyed. The box

elaborate, so long as it provides reasonable privacy and shelter. The pit should be made flyproof by means of a tight fitting riser, seat, and cover. A low mound of earth should be tamped around the base of the privy to divert surface drainage and help keep the pit dry. Accumulated waste should be covered with not less than 12 inches of earth when the privy is moved or abandoned. Outdoor toilets should not be located in areas that are subject to flooding, and should be built at least 50 feet from any well, spring, or other source of water supply. Otherwise the wastes may contaminate the water. Or, they might be washed out of the pit and deposited on the ground surface where they would be exposed to flies, rodents, and other animals that might serve as disease carriers.

(e) Persons in city apartments, office buildings, or homes without yards should keep a supply of waterproof paper containers on hand for emergency waste disposal. Where flush toilets cannot be used and open ground is not available for the construction of privies, such disposable containers offer a practical method of emergency waste collection and disposal. Building managers should plan for the collection of such containers and for their final disposal. Before collection, the used containers may be stored in tightly covered garbage cans or other waterproof utensils fitted with lids. Homemade soil bags for this purpose may be prepared very easily by putting one large grocery bag inside another, with a layer of shredded newspaper or other absorbent material between. Apartment dwellers should have sufficient grocery bags on hand now for possible emergencies. A supply of old newspapers will come in handy for other sanitary uses, too, such as wrapping garbage and lining larger containers.

(f) Insecticides and deodorants should be used when necessary to control odors and insect breeding in containers that cannot be emptied immediately. At least 2 pints of household bleach solution should be kept on hand for disinfecting purposes.

(g) Keep on hand an extra supply of toilet tissue, plus a supply of sanitary napkins. If there is illness in the house that requires rubber sheeting or other special sanitary equipment, make sure that adequate supplies are available. At least a week's accumulation of daily newspapers will come in handy for insulating bedding from floors, and lining clothes against cold, as well as for the sanitary uses already mentioned.

(b) If you have a baby in your home you may find diaper laundering a problem under disaster conditions. It is best to keep an ample supply of disposable diapers on hand for emergency use. If these are not available, emergency diaper needs can be met by lining rubber pants with cleansing tissue, toilet paper, scraps of cloth, or other absorbent materials. Or, any moisture-resistant material can be cut and folded to diaper size and lined with such absorbent material.

DISPOSAL OF GARBAGE AND RUBBISH

Garbage may sour or decompose; rubbish will not, but offers disposal problems in an emergency. Garbage, or any mixed refuse containing garbage, must be carefully stored and handled if odor and insect nuisances are to be prevented. Since rubbish alone is fairly easy to dispose of, garbage should be kept separate from it and not mixed. The following suggestions will make it easier for you to take care of the refuse problem:

(a) Garbage should be drained before being placed in storage containers. If liquids are strained away, garbage may be stored for a longer period of time without developing an unpleasant odor. After straining, wrap the garbage in several thicknesses of old newspaper before putting it into your container. That will absorb any remaining moisture. A tight-fitting lid is important to keep out flies and other insects.

(b) You should keep one or more 20-gallon garbage cans on hand for emergency use, if possible. If you live in an apartment building, get the largest kitchen garbage container for which you have space.

Final disposal of all stored garbage and refuse can be accomplished in the following manner provided there is no danger from radioactive fallout:

(a) All stored garbage should be buried if collection service is not restored. If unpaved yard areas are available, keep a shovel handy for this purpose. Do not dump garbage on the ground, because that attracts rats and other scavengers. Dig a hole deep enough to cover it with at least 12 to 24 inches of dirt, which will prevent insect breeding and discourage animals from digging it up.

(b) Do not establish a community dump without permission from proper authorities. Garbage dumps quickly become infested with rats capable of carrying disease germs over a wide area. If necessary, local authorities will pick sites where refuse may be left for supervised burning or burial as soon as conditions permit.

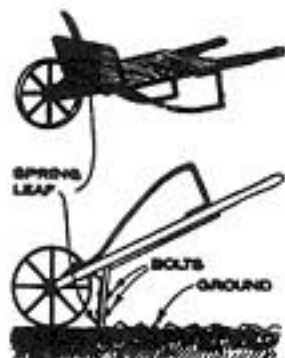
(c) Other rubbish may be burned in open yard areas or left at dumps estab-

is mounted on the door jamb, with the open side against the door. Only the mail slot is exposed when the door is closed.

Garden Plowed with Wheelbarrow

(FROM POPULAR MECHANICS 1919)

The sketch shows how an ingenious gardener quickly converted an ordinary garden barrow into a serviceable cultivator. A leaf from a broken automobile spring, 2 ft. long, was secured to the dash of the barrow by means of two short bolts, put through holes drilled for the purpose. The other end of the spring was cut to the shape of a narrow cultivator shovel, and sharpened. To use the plow, the barrow was simply turned upside down and pushed along the row after the manner of a wheel hoe. Later, two smaller shovels, made from leaves of a seat spring, were bolted one on each side of the large one, to form a weeder. The cultivator does not interfere with the regular use of the barrow.



A Weeding Tool

A handy weeding tool may be made of an old case knife—one of the kind having a wood handle is the best. Remove the handle sides and heat the blade about 1 in. from the end, then bend it at right angles as shown at A. Ream out the rivet holes in the handle large enough to allow screws, about 1 in. in size, to enter. Procure an old broom handle and saw a slot in one



A Case-Knife Blade Bent and Fastened in a Broom Handle Makes an Excellent Weeding Tool

end deep enough to receive the knife shank, and fasten it with screws, as shown at B. This makes an excellent tool for removing weeds from beds of young radish, lettuce and other plants, as it is possible to get close to the plant stem without injuring it.

Rubber Bands Made from Old Inner Tubes

Old inner tubes of bicycles, or other vehicles, may be cut into rubber bands of various widths which will be found to give good service. The tubes should be laid flat on a hard piece of board, or a piece of sheet zinc, and the bands cut off one at a time with a sharp knife held against a straightedge. In cutting them on wood, it is best to use a close-grained stock and to cut across the grain of the wood.

lished by local authorities. Cans should be flattened to reduce their bulk. Do not deposit ashes or rubbish in streets or alleyways without permission. Such material may interfere with the movement and operation of fire-fighting and other emergency equipment.

PROPER DISPOSAL OF GARBAGE AND RUBBISH

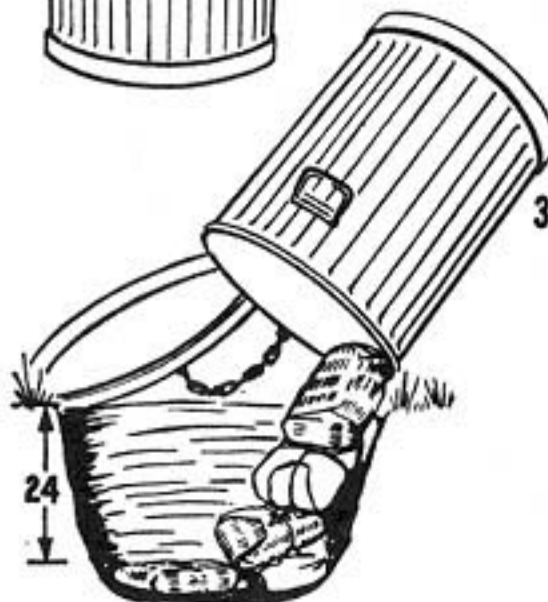
1. Liquids should be drained from garbage.



2. Garbage should be wrapped and placed in a large container with a tight lid.



3. Garbage should be buried as soon as possible under 12 to 24 inches of dirt.



4. Rubbish other than garbage may be burned . . . but safety precautions must be taken.



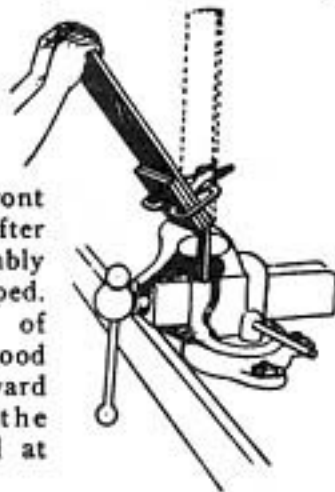
HERE'S WHAT YOU NEED FOR EMERGENCY SANITATION

1. Stored drinking water or other liquids to quench thirst (7 gallons for each member of your family).
2. A 2-week supply of proper foods for your family, including milk. (This can include food already in your refrigerator, plus canned or packaged foods on your cupboard shelves.) Also store paper plates and napkins.
3. Towels for emergency table use, plus cooking and eating utensils, measuring cup, can and bottle openers, pocket knife, and matches.
4. Canned milk for baby, and emergency canned foods for diabetics or others requiring special diets.

How to Bend Heavy Sheet Metal at Sharp Angles

From Popular Mechanics 1933

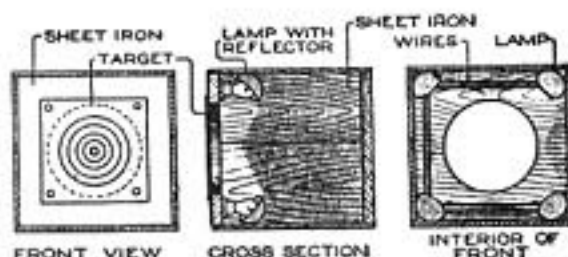
For bending heavy sheet metal, mark the work at the point where it is to be bent, and place it in a strong vise with the top of the mark just above and parallel to the top of the jaws. A piece of 1 by 4-in. wood, 2 or 3 ft. long, is placed on the back, and a smaller piece of sheet metal is placed in front of the work, after which the assembly is securely clamped. Grasp the top of the piece of wood and pull it forward slowly, and the work will bend at a sharp angle.



AN ILLUMINATED INDICATING TARGET BOX

From Popular Mech. 1919

The joys of target practice are often hampered by the delays in the settlement of hits. It takes time and is



The Location of Hits is Recorded by a Beam of Light Streaming through the Hole Shot in the Paper Target

annoying to be constantly advancing to the target to examine it. To do away with this, an illuminated target was constructed that enables the shooter to locate every hit without leaving his post. To make the device, a square wooden box of convenient size is obtained. In one side of this, cut a round hole as large as the largest ring on the targets used. The side opposite this is fitted with a piece of sheet iron to stop the bullets. Paint this iron and the interior white. Inside the box, arrange four electric lights so their rays will be thrown on the hole, as shown. Candles may be used, if necessary. The lamps must be out of range of the bullets, that hit the target, and protected by an iron plate. The targets, painted on thin paper, are fastened over the front of the hole, and the

5. At least one large covered garbage can (20-gallon size, if you are a householder) to keep garbage until you can dispose of it.
6. At least one smaller garbage can with tight-fitting lid (10-gallon size) as a container for human wastes.
7. A covered pail or other receptacle that can be used as an emergency toilet, if water is not available to flush household fixtures.
8. A supply of soap, toilet tissue, sanitary napkins, and disposable diapers (if there is a baby in the house).
9. If there is illness in the family, spare rubber sheeting, extra medicines, and a reserve supply of any special equipment needed by the patient.
10. A supply of grocery bags (large) and a week's accumulation of daily papers, for soil bags, garbage wrappers, and other sanitary purposes.
11. Household chlorine solution (2 pints) for purifying drinking water, and 1 quart of 5 percent DDT solution for use against insects.
12. Screwdriver, wrench (for turning off valve on house water service line) and shovel (for burying garbage and other wastes), and other tools.

FOR PROPER SEWAGE DISPOSAL YOU WILL NEED . . .



1. Covered container for bathroom



2. The materials to make soil bags



3. Newspapers, extra toilet tissue

4. Insecticide and deodorants

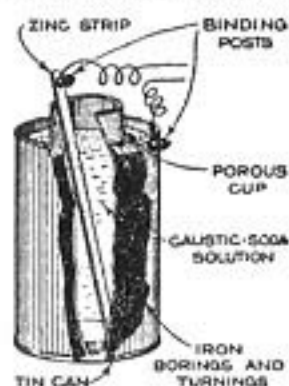


lights are on, while shooting. Each shot punctures the paper, and the light streaming through the hole will show the location of the hit.

A Cheap Wet Cell Battery

From Popular Mechanics 1925

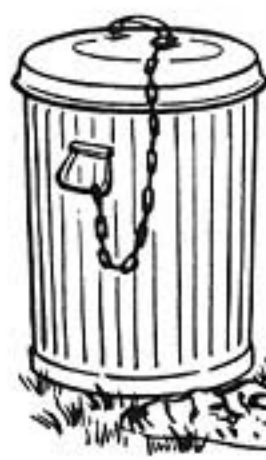
The high cost of dry cells has encouraged many to make and use homemade cells of various kinds, and the one described has the merit of cheapness and efficiency, as well as long life. For the battery jar, an old can, about 6 in. high and 4 in. in diameter, is used. A porous cup is required, and this is made by rolling a strip of blotting paper around a stick, 1½ in. in diameter, and securing the ends with melted paraffin. The bottom of the cup is made by standing it on a smooth surface which has been greased with vaseline, and pouring in plaster of Paris, or melted paraffin, to a depth of about ½ in. When completed, the porous cup is stood in the center of the can, the outside space is filled with chips, borings, and turnings of iron, and a strip of zinc is placed inside the cup, as shown in the drawing. The battery solution is made by dissolving caustic soda in water until it will take up no more; a saturated solution, in other words. The cell is filled with this solution to within an inch of the top, and connection is made with the zinc strip and the can by means of binding posts, as shown. Owing to the caustic character of the battery solution it should not be allowed to come into contact with the skin or clothing. Such a cell has a voltage of about 1.2, and will deliver approximately two amperes on short circuit, depending on the purity of the chemicals and the fineness of the borings and turnings. The internal resistance of these cells is high, and best results are obtained by connecting a battery of them in parallel, if a large amount of current is required. However, one or two such cells will give good results for light service, such as a doorbell circuit.



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Birds and Blue Paper

Some interesting experiments that have been conducted show that seeds and crops may be protected from the attacks of birds by the use of blue paper. Strips of bright-blue paper tied to strings were stretched across seed beds, and no birds ventured near. Pieces of blue paper were also attached to fruit trees, and the feathered robbers carefully avoided the position.



5. Tightly closed can for emergency storage of body wastes



6. Shovel

EVERY AMERICAN SHOULD LEARN:

1. Warning signals and what they mean.
2. His community plan for emergency action.
3. Protection from radioactive fallout.
4. First aid and home emergency preparedness.
5. Use of CONELRAD—640 or 1240 on AM radio—for official information and instructions.



SUMMARY

PREPARE NOW TO TAKE CARE OF YOURSELF AND YOUR FAMILY

Unsanitary conditions can disable you in a disaster. If an emergency occurs, keep calm. Drink only water that you know is safe. Eat only safe food that has been prepared under safe conditions. If you cannot be sure that the things you want to eat or drink are safe, go without until help comes.

Prepare now to take care of yourself and your family. If your home resources fail, don't lose your head. Do the best you can to eat and drink sensibly and protect your health until help can reach you.

An enemy attack would be primarily an attack against people. Illness and epidemics would be part of that attack. Its aim would be to knock the civilian population out of the war. Don't help the enemy by putting yourself out of action through carelessness. Emergency feeding and sanitation measures can keep your family on its feet.

Fake Cats Scare Birds and Mice to Save Scotchman's Crop

Modern Mechanics 1935

CRAFTY are the birds and field mice that eat the farmer's seed as it is planted; craftier than they is William H. Randall, a land-owner in Southern Scotland who, finding the futile flutterings of the ordinary scarecrow a poor guard against hungry scavengers, has enlisted the aid of an army of cardboard cats to guard his crops.

Painted white on one side and black on the other with grotesque eyes and whiskers, they are almost perfect crop savers.

The cats are cut from stiff cardboard and nailed to laths so that they may be set in the soft soil of a newly planted field. After the seeds have germinated and formed roots, the cats are pulled up and saved for the next sowing.

Randall and his family are shown setting up cardboard cats to keep birds and mice from digging the newly planted seed from the ground.



Christmas Number
OF
HARPER'S YOUNG PEOPLE.

DECEMBER 19, 1882.

CHRISTMAS is coming! How many weeks have you been thinking about it, little people? A good many, have you not? Well, now, how long do you suppose the publishers of HARPER'S YOUNG PEOPLE have been thinking about it? How you will laugh when we tell you that last August, when it was so warm that people went about in straw hats, waving fans, and cooling themselves with long draughts of ice-water, the publishers of HARPER'S YOUNG PEOPLE had already begun to consider what should be done for Christmas. Wasn't that an early start? You were eating peaches and bathing in the surf, and we were here, hard at work, getting ready for Christmas.

Well, now you see what comes from all this activity and industry. Old Santa Claus, easy-going and lazy, hasn't begun to think of harnessing his reindeers yet, and here are we all ready to give you rich feasts of Christmas fun two weeks before the time. This week you will see that HARPER'S YOUNG PEOPLE is nearly all given over to Christmas, and yet it is only a foretaste of what we have in store for you when the "Christmas Number" appears. Next week open your eyes wide, and look out for "The Christmas Number of HARPER'S YOUNG PEOPLE." You remember what it has been in other years, and this year it will be better than ever. Mother Goose and Santa Claus will come flying along on the cover; Miss Sophie Swett will tell you a delightful story about "The Girl who Saved Up Christmas"; Jimmy Brown will describe the awful scrape he got into, all through the "Snow Man" he and the other boys built on Christmas-eve; Mr. Will Carleton will tell you a lovely story in verse of what came to a little girl through "A Christmas Prayer"; Mr. Matthew White, Jun., has a charming story to tell about a young boy who was "A Christmas Knight"; and Miss Olive Wilson will give you a delightful little play called "The Old Woman in the Shoe," which you can all get up without difficulty for Christmas-eve or some other pleasant holiday-time.

Then, last but not least, Mrs. Margaret Sangster will give you a "Christmas Carol," which has been set to sweet and simple music. Many of you can play, and nearly all of you, we know, can sing.



BROOKLYN, NEW YORK.

How delighted we are, dear Postmistress, that you have proposed having a sort of grand conference whereby we can assist each other in making presents for the coming Christmas! We take great pleasure in contributing the little we know. To make gifts with as little expense as possible will, we presume, be a matter of importance with most of us little girls, as we all have quite a number of relatives, and we don't want to leave any of them out in the cold on Christmas morning.

First, get some old honey or mustard bottles; select those that have a nice shape; paint them (by pairs) either in terra cotta, black, or a very pale shade of olive; when thoroughly dry, touch the neck and top with gold paint; finish with some pretty scrap picture pasted on the front. You will be richly rewarded for your trouble when you see what a tasty pair of vases you have made. A box of gold paint can be bought for

THE MARCHING MORONS

By Kurt Saxon
(Harper's and Godey's articles referred to are to the left and at the end of this editorial)

THE MARCHING MORONS is the title of a classic science fiction novelette by C.M. Kornbluth. It can be found in most any library in the book BEST SCIENCE FICTION STORIES, 1952 and has been published in paperback.

The story takes place several hundred years in the future but is a shockingly realistic picture of our own times. Kornbluth must have been a real optimist to put it so far ahead. Actually, the low level of intelligence in 1978 would be enough to doom world civilization even if my other projections were inaccurate.

Basically, the story deals with a person who goes to sleep under anesthesia in our time and is awakened in the far future. He is shown that the Earth is flooded with morons and the average I.Q. is 45. (U.S. tests have gone out of fashion now; scores have become so low.) The overwhelming majority are unfit for any useful work so the able future types are their virtual slaves. The population of the world is five billion. (Ours is four and a half billion.)

The main reason given for the problem was that the intelligent left childbearing to the ignorant and the I.Q.s went down more and more as the dummies procreated increasingly. What with our own "intelligent" classes having fewer children and the faggots taking more good genetic material out of the gene pool, our morons are marching today.

Kornbluth's heroes believed the problem would have been solved by more of the intelligent reproducing. I disagree. The problem would have, and could have been solved in our time, if the less intelligent had been sterilized. The idea of the two classes trying to outbreed one another could only lead to the surplus population which was, and is now, the actual basis of the problem.

The story is hilarious but will make you squirm to see how close it fits our own time. If you haven't already read THE MARCHING MORONS, do so and you will better understand the following.

THE MARCHING MORONS will make you think of Ayn Rand's ATLAS SHRUGGED (See Vol. 1, page 139) and my own editorials on dummies, (Vol. 1, pages 64 and 84).

It has been broadcast increasingly that college entrance scores are getting lower all the time. Now predictions are out that by the year 2000, Americans won't be able to read at all.

The TV commentators say this is the fault of Television. As bad as most TV is, this is simply not true. Children attend school for five hours a day for five days a week. Aside from a few non-reading subjects, any normally intelligent child would pick up the reading of basic English in a few months, simply by exposure.

I learned to read long before I went to school. From the age of four, on, I would ask my parents and brother and sister what certain words were in comics and the Sunday funnies. I just picked up the skill gradually, as a matter of course.

My mother had bought a complete set of the works of Mark Twain and read to us nightly from TOM SAWYER, HUCKLEBERRY FINN and on through PUDDENHEAD WILSON. Both she and my father were raised in Arkansas and both graduated from the eighth grade in one room, ramshackle country schools.

Mom never read a book on her own, except the Bible and Dad only read Western pulps. But they could read as well as anyone. They were simply peasants with no intellectual leanings. By modern standards they were ignorant rednecks and their speech and accents were crude, but they had native intelligence.

Grandma, on my mother's side, couldn't read her own name. But her children had the opportunity and, like it or not, they had to take advantage of it. I remember either Mom or Aunt Lydia telling of not paying attention one day and the teacher threw a chestnut at her and she had a lump on her forehead for three days.

twenty-five or thirty cents, and with it you can work wonders. It adds greatly to the beauty of plaques to touch their outer rim with gold paint.

If you have a fancy straw hat that is out of season, rip it to pieces, being careful not to cut the braid; cut a piece of pasteboard the shape of a cornucopia; slightly dampen the straw, and sew on the pasteboard in rows overlapping each other; when dry, give it one or two thin coats of gold paint; line the inside with pale blue silesia; trim the top edge with a row of red pleated ribbon, join neatly in the back, put a loop at the top to hang up by, and a bow and ends of ribbon on the lower point. This will be an elegant hair-receiver for mamma.

Get a stout round box about as large as a tea saucer and three or four inches deep; cover neatly inside with pale blue or old gold silesia; paste a scrap picture on the inside of the cover; cut out of cardinal Canton flannel a round piece for the outside of the cover, or use, if you prefer it, either silk, satin, or velvet; put a straight band of the material around the side of the cover, and stitch lining and outside together on the edge with old gold embroidery silk; fasten a strip around the bottom part in the same manner, and finish with a fancy ribbon put straight around the bottom part, and fastened on one side; a bow on the top of the cover completes a cuff-box for papa. A set may be made—one box for collars, and one for cuffs. A box of this kind makes a pretty receptacle for tobacco.

Beautiful tiles can be coaxed out of cast-off ribbons. Take two strips six or ten inches long, according to width; sew lace insertion between the two strips of ribbon, and finish with lace edging all around. The ribbon strips may be improved by embroidery. Patterns may be traced on ribbons or squares of poplin or satin by the aid of carbon paper.

School bags may be crocheted out of macramé cord, and they are both durable and pretty. The things that can be made from the bright and pretty Canton flannels are indeed wonderful—small table spreads, stand and chair scarfs, and numerous graceful articles useful in a home.

We fear that by this time the dear Postmistress is looking fierce. We will give you just one idea of a chair scarf, and from this you can form many others. Cut some cardinal Canton flannel the length and width the chair requires; a piece of old gold flannel is put across the end eight inches on one side and three on the other, and sew furniture fringe across the end; where the two colors join turn in the raw edge, and work with silk (red shaded) in herring-bone stitch. The edge of the sides is finished in the same manner; or narrow velvet is laid on the edge first, and then worked with fancy silk in herring-bone. Cretonnes may be used with pleasing effect.

GRACE and MABEL D.

You dear little women, how can you imagine that a Postmistress could look anything but delighted with so bright and so well-expressed a letter as this. You have described a number of pretty gifts so very plainly that I think a good many small fingers will set to work to see what lovely things they can contrive from odds and ends by the aid of a little home magic and a few inexpensive materials.

GREENPOINT, NEW YORK.

The boys in our street have asked me to write to the Postmistress, and ask her what she thinks about fighting. There is a set of fellows from another part of the town who keep coming at us, and attacking us with clubs and stones, whenever they get a chance. Father says if they don't stop they'll find themselves arrested soon, for they have broken some windows and carried off area covers. He says we must ask the policemen to drive them off. Mother wants to win them over by kindness, and she and some other ladies are going to get up a Christmas tree, or something like that, to please them. I sha'n't go to it. But we boys think the best way will be to have a fair square fight, and settle the business. We mean to fight and drive them off, and our captain, Harry D., isn't afraid of anybody. Please tell us your opinion. Charlie B. writes this, but we all join in signing our names.

CHARLIE B., JOHN N., JOHN S., and FRANK T.

I suppose if I say that I agree with your mother that in the long-run nothing succeeds like kindness, you will say: "There! just what we

In those times, kids were sent to school to learn reading, writing and arithmetic. Discipline was harsh and if a child simply wouldn't learn, he was sent home and pronounced feeble-minded. Thus, parents always sided with the teacher and the children learned whether they wanted to or not.

On my first day at school at P.S. 82 in Brooklyn in 1938 things went well enough as my teacher began with the ABCs which I hadn't learned. I knew words but what was the use of the separate letters?

While I was learning the ABCs I was reading the first grade reader, which I wasn't expected to get into for several weeks. It's main story went something like this: "The red squirrel ran up the tree and got an acorn. Then he ran down the tree and dug a hole. He put the acorn in the hole and covered it." It was certainly on a higher level than "See Spot run", but I didn't care for the plot.

I told the teacher I wanted to read about knights and sword fighting instead and she told me the book was for learning to read; not for fun. She also said parents shouldn't teach their children to read because that was the teacher's job.

I told Momma and she said the teacher was a fool but I shouldn't tell her so because she was a Yankee and didn't know no better.

Actually, both the teacher and Mamma were right in their own ways. In a one room school with all eight grades being taught to children of various ages by one teacher, a child could proceed at his own pace. One child could be learning third grade arithmetic and fifth grade reading and second grade geography and still be listed as in the fourth grade on his report card.

In the city schools, however, one teacher taught one group of children of the same age the same level of every subject. Also, the whole class had to study the same chapter at the same time. So when the teacher was teaching the other kids how to read the squirrel story I was shooting paperwads with a rubber band.

I will proceed to prove that the one room, multi-grade school house gave the best primary education. However, I don't mean to imply that the so-called progressive schools, working on somewhat similar lines are anywhere as good. They are playpens. The children do what they want to. If they would rather play with clay or cut out paper dolls, that's what they do.

In the old one room schools a child might work at various grade levels. But he didn't play, except at recess. Come arithmetic time he might be on the second grade level while the child next to him was on the third. But they both studied arithmetic. They had no choice as to subject; only the level of the subject. And rather than being forbidden to copy one another's work, those who knew more were expected to help those who knew less.

Concerning arithmetic; when I was in the third grade in Chicago, I was sick and missed a couple of weeks when the teacher was giving a course in a kind of multiplication. I came in on the day of the test and hadn't learned how to solve the problems in the test. Somehow, I figured out a different method and got all the answers right.

My teacher admitted I got all the answers right but I got a zero for not doing it her way. I was so furious I never learned any more arithmetic while in grade school. In future tests I just figured out my own methods and got barely passing scores from then on.

Of course, I still did well in reading. At age 11, I was on a first year college level of reading and comprehension. I was ahead of my class at that time but it's a fact that today, the average first year college student reads and comprehends below the level of the average 11 year-olds of my day.

I was quite sickly so I was 16 when I got out of grade school. They seldom skipped students then so if one missed a lot of school he had to make up the time regardless of how much he knew. I didn't bother to go to high school. I would have been three years older than the first year high school students. But also, I knew that most high school students were stupid and the curriculum was Mickey Mouse. A later G.E.D. test, about 1955, showed I had an overall score of 85%, whereas 70% was passing for the average high school graduate.

Now, I'm not bragging. I'm just saying that the achievement levels were

expected from the Postmistress! Women never approve of fighting for one's rights!" I own, boys, that I dislike all rough quarrels, and think that they should be avoided if possible. And yet there are times when it is necessary to show that a boy has courage and pluck. I am afraid that you have hurt the feelings of those boys by acting as though you were better than they. Perhaps you have aroused their anger by boasts, or by daring them to come on your ground. I would not fight if it can be helped; but if obliged to fight, I would, if I were a boy, do my part manfully. If I saw a boy of my size ill-treating a little one, do you think I would walk off and not interfere? And if I saw a crowd of boys worrying a poor dog or pussy cat, wouldn't I go to the rescue? That I would. And I would not join in the wicked merriment of ill-bred boys who make fun of people because they are not quite bright in their minds, or have a defect of some kind.

If the trouble must come, and you are not in any way the offending party, then stand up for your rights. If they should attack you, your captain must first be sure, like a good general, that his forces are strong enough to meet the aggressors, and then, if possible, drive them away, and frighten them so thoroughly that they will never annoy you again.

Have you ever heard what Thomas Hughes has to say on this subject in "Tom Brown's School Days"?—a book which every boy should read:

"After all, what would life be without fighting, I should like to know? From the cradle to the grave, fighting, rightly understood, is the business—the real, highest, honestest business—of every son of man. Every one who is worth his salt has his enemies, who must be beaten, be they evil thoughts and habits in himself, or spiritual wickednesses in high places, or Russians, or Border-ruffians, or Bill, Tom, or Harry, who will not let him live his life in quiet till he has thrashed them....

"As to fighting—keep out of it if you can, by all means. When the time comes, if it ever should, that you have to say 'Yes' or 'No' to a challenge to fight, say 'No,' if you can—only take care you make it clear to yourselves why you say 'No.' It's a proof of the highest courage, if done from true Christian motives. It's quite right and justifiable, if done from a simple aversion to physical pain and danger. But don't say 'No' because you fear a licking, and say or think it's because you fear God, for that's neither Christian nor honest. And if you do fight, fight it out; and don't give in while you can stand and see."

PETERSBURG, VIRGINIA.

Please tell me what you charge for putting an exchange in your paper.

I go to school. I am in Division of Fractions. I got a paper from Indian Territory to-day. I get plenty of papers, and stay in the house at night and read them and study my lessons.

CLAYTON S. T.

There is no charge for the insertion of an exchange.

One sentence in your letter pleases me so very much, Clayton, that I must call the attention of the boys to it. It is that you spend your evenings in the house studying and reading. This is a much better and, on the whole a happier, way of spending them than those boys have who are not contented with merry play by daylight, but want to go out evenings as well.

Did you ever hear a jingle I used to say when I went to school:

"Multiplication is vexation,
Division's just as bad,
The Rule of Three it puzzles me,
But FRACTIONS drive me mad!"

NAPLES, ITALY.

I am a little girl nine years old, and love fun and novelty, and I would like to tell the little boys and girls in America about a fair which was held in the public garden here in Naples for the relief of the sufferers from the floods in Northern Italy. Papa, my brother, and I went to it. At the principal entrance to the garden, which is

going down by the year. I could see them go down. I wasn't necessarily smarter than the people of my own age. Younger people were just less competent.

I found this out when I was urged by a teacher I met to go to junior college at the age of 26. I was older than most of the students but I was shocked at their ignorance, since they had graduated high school but were less educated than I.

Wanting to take German, I found that I knew nothing of sentence structure. This knowledge was essential to learning a foreign language so I had to take dumbbell English. I was amazed to find that the other students in that class were there, not from technical ignorance, but because most of them couldn't even read at a fifth grade level. How did they graduate eighth grade and go through high school? This was in 1959.

In my college entrance test I got over 90 percentile in English usage and only 20 percentile in math. I had decided to take algebra but the teacher threw me out of the class and I had to take dumbbell arithmetic. In one semester I rose from 20 percentile to 60 percentile with a B.

But here's the clencher. The other students in dumbbell English and math showed little, if any improvement. They had had the exposure, which I had lacked. But they simply didn't have the brains to learn. Again, this was in 1959.

As the years have gone by our youth has had more exposure to knowledge than anyone in history. But they are virtual morons and their ability to function socially is lessening each year.

Lest you think this is my typical raving, I have below, comparisons of the average intelligence of children of the 19th Century. Following are two pages from the letter columns of HARPER'S YOUNG PEOPLE, Dec. 19, 1882. It was written for children from three years to about 13, since those older were more into formal education or already working by that age.

On reading the first part, notice the vocabulary and the expectation that many of the little readers could actually play the Christmas carol advertized for later. Following are the letters of little children and their answers by the "Postmistress". You might expect some spelling was corrected but the words were those of the children.

Grace and Mabel D. were probably about eight or ten. Yet, their vocabulary would pass muster in any modern college.

The three boys asking about fighting were answered by a woman; not an empty headed Liberal bitch of today who would have advised them to give the "underprivileged" attackers anything they wanted.

Could your nine-year-old write such a description of living in Italy as did the 19th Century American girl, Mamie D.?

Harry J. was just an average boy of his day. But his exuberance and natural love for his family members would be refreshing today, compared to our bored children who see their relatives as only a drag.

Edna P.S. did not whine for money to buy gifts. She wanted ideas on how to make them for her loved ones. Where are the Ednas of today?

Athelstane K., seven, could not only write, but he could read "Nan", a children's story in HARPER'S YOUNG PEOPLE with concepts and the vocabulary few highschoolers could get through today.

Eight-year-old Edith L.'s letter is charming but unexceptional for her era. The same goes for that of Oliver P., seven.

Now, Gracie Emerson M. read HARPER'S YOUNG PEOPLE to herself at the age of five. Her reference to her ability to type is to be believed. However, she admits her papa typed the letter. I suppose it was an old Oliver. A child could use the Oliver when it was new. But as it began to wear, tiny hands could not manage the increasingly sticking keys. Yet, I have no doubt the words were hers.

The last entry, a memorial to Eddie Shiffler, paints a picture of a boy, the kind of which made our nation great. The universal lack of his kind today has doomed world civilization as surely as would a full-scale nuclear war.

called Villa Nazionale, were four great elephants, not live ones, but frame-work covered with canvas. There were a great many bazars inside. One was a doll bazar; this was shaped to represent a tremendous doll looking out from a walking-basket, such as the Neapolitans put their babies in when they are learning to walk. Outside of this basket bazar were hung drums, dolls, and all sorts of playthings, the selling of which went on at the door. Just opposite to this was a flower bazar, which had its back against a statue. And what do you think the back was? A looking-glass. This bazar was like a bower of willows dotted with flowers that had the faculty of standing without the least support. Then there was a cigar booth which looked very much like an Indian wigwag; it was built of mock cigars, each one reaching from the ground to the top of the wigwag.

In the garden where the fair was held there is an aquarium. The director of it gave all the

money made by it that day for the benefit of the fair. About twenty-five thousand people went to the fair, so of course a great many went in to see the aquarium. One of my dearest friends, a little girl named Beatrice, went in. She ascended to the top of the house to take a bird's-eye view of the fair, and fell through a skylight into the room below, which was locked. She was unconscious when she struck the floor. The key could not be found, and when they were about to break down the door she came to her senses, and called out, "I'm all right." Just then the key was found.

The fair closed with fire-works in the evening, which I did not see. I was disappointed, because there was an electric Punchinello, which must have been funny.

MAMIE D.

What a pity your little friend met with such an accident! I hope she soon recovered from the shock it gave her.

Your description of the fair is very well written, and I wish I could have gone with you to see the wonderful make-believe elephants, the flower bazar, and the lovely dolls. The best thing about it all was that the money, which no doubt flowed freely into the treasury, was given to help those who were in need.

Now we will take a journey from Naples to New York.

Little folks who go shopping in this busy city are familiar with the shrill cry of "C-a-a-s-h!" by which the saleswomen summon the girls who carry parcels and go on errands in the crowded buildings. I sometimes look at these quick-witted and light-footed little errand-girls, and wonder what sort of homes they have, and hope, especially when I see a tired look on their faces, that their parents will not be themselves too weary with the day's work to give them a kind welcome home at night. And now, when you read the true story which a lady writes for the Post-office Box, I am sure you will feel that one little girl deserved credit for being above the temptation to take what was not her own:

Very recently in one of our large shops on Sixth Avenue a little "cash girl" picked up some money. The rule in all these establishments is that articles dropped or forgotten by careless customers shall be carried to the "Found" desk; but if a clerk is dishonest, this rule can be evaded. The little girl was honest, and therefore took the money to the proprietor of the shop. Some time during the day a young man came in, asking if a hundred-dollar bill had been seen; he could not be positive, but he thought he had lost it there. It was proved that he was the owner of the found money, and so pleased was he to know that a little girl had been honest enough to place it where it could be claimed that he asked to have her presented to him, and gave her forthwith twenty-five dollars. The proprietor of the store thought it would be unsafe to allow the child to go home alone with what was, for her, so large a sum of money, for the untaught street children are bold little thieves, so he went home with her. He found the family dreadfully destitute; the mother and older daughter were both ill and in bed; the rent was due, and but for this timely gift all the family would have been turned into the street the very next day. Were not these deeds of honesty and kindness beautifully blended? and do you not think that little girl must have been glad and proud thus to have saved her dear ones so

An example of our government's acknowledgement of the imbecility of the average American, the J.T. Baker Chemical Co. and most others have sent restriction lists to all their representatives. Such lists are aimed mainly at potential illicit drug manufacturers. An addendum to the Baker list, having nothing to do with narcotics, is the injunction: "Do not sell: Carbon disulphide, carbon tetrachloride, any cyanides, turpentine (?), potassium hydroxide (wood lye), nitric acid, sulphuric acid, any nitrates, any chlorates, hydrofluoric acid."

Skipping to another subject of 1860 is a selection of editor's rejects. Aside from ignorance to spelling and Cora and Dora Dodd's flaunting their vocabulary, most of these rejects are far better, more intelligent and full of sheer wit and comedic talent than is printed in the best publications today. (I'd have given \$10.00 simply for J.J.s line from THE SLAYIN PARTY, "The nite before the sno had snu,").

Although I can sympathize with the editor of that time, I only wish most of the pieces sent to me had a tenth of that talent shown here.

Now we'll go back to 1861 when intelligence was even higher. GODEY'S LADY'S BOOK AND MAGAZINE carried a course in CHEMISTRY FOR THE YOUNG. Again, pre and early teens with little formal education. Notice, the writer calls the experiment a "simple case". (College chemistry today). And could a modern American go to the "Philosophical instrument maker" and have such an apparatus made for a child's experiment?

Passing on to lesson XX (20) I reproduce only the first paragraph, listing the required ingredients for another experiment: Phosphorous, ammonium nitrate, nitric acid and oil of vitriol (sulphuric acid). All of these are impossible to get by children today. Nowadays they lack judgement and skill to be trusted with such chemicals.

Although most of the humor of the 19th Century does not appeal to us, due to different frames of reference, "Miss Prymm on Babies", GODEY'S, 1872, written by a woman, is a monologue Joan Rivers or any other comedienne could use commercially.

We of the 20th Century have been led to believe that women of the 19th were bubble-headed dummies, protected from reality and able only to read and understand cooking and flirtatious romances. The average woman of the 19th Century, with any education at all, was far more intelligent than the men and women of today.

Imagine WOMAN'S DAY printing a complete description of the manufacture of gunpowder. The average woman of today could barely read it, much less understand it. Yet, it is a treatise worthy of inclusion in any modern textbook explosives.

So, you see, although we have an accumulation of knowledge undreamed of then, our people are mental midgets, compared to 19th Century Americans. Our only hope of survival in the near future is to abandon modern concepts of progress and the idea that we are somehow superior to our ancestors.

The average modern American is a feeble-minded degenerate and is being led to the slaughter. The morons are marching, even now. And if you march with them, the death of the inferior will be your just and inevitable reward.

much suffering?

In your pleasant planning for Christmas, dear children, I trust you are all remembering those who are not so comfortable as you are. There is a great deal of suffering in the world in the merry winter days, when the snow-flakes fall, and you, who are warmly clad, have so much fun. You will be the happier if you do your share in making some cold bare home brighter and warmer.

and made such a racket that papa came to the foot of the stairs and called, "Boys! boys! what are you about?" Then sister came to the door and said there were buckwheat cakes, and we must hurry and get dressed for breakfast.

I have a sled, and I take my little cousin Helen to school on it. I like to skate, and so do Ned and Clark, my two brothers. On holidays papa and Uncle John go and skate too. And you ought to see papa, he skates so nicely!

Good-by.

HARRY J.
EAST LIVERPOOL, OHIO.

NEWARK, NEW JERSEY.

Hurrah for the snow! When I jumped out of bed this morning, and saw the street all white, I was so glad I gave three cheers. My brother Ned woke up, and he ran to the window and opened it, and made a snow-ball of the snow on the sill. He threw it at me, and oh! it was splen- did and cold! We had a grand pillow fight then, house one night. I take your delightful paper, and read all the letters in the Post-office Box, and I thought I would write one myself, although I have not any- thing very interesting to say. But I guess I will tell you about an owl that made a visit at our house one night. Mamma and I were just going

out in the hall when we heard a noise upstairs; it sounded like an animal; it flew, and alighted on the gas fixtures. Mamma and I were so frightened that we didn't know what it was. I ran for papa, and he caught it, and found it to be a great owl; he did not keep it, but let it out in the yard, and that was the last we saw of it.

Dear Postmistress, it is about time to make Christmas presents, but it is so hard to know what to make that I haven't got very many made yet. Have you? EDNA P. S.

The owl was probably as alarmed as you were, when he found himself in such strange quarters. I have not time to make many of my Christmas gifts, dearie; this Post-office Box keeps me so busy. But if you read the letters in this number you will get a good many bright ideas, and you may try to put some of them in practice.

HOBOKEN, NEW JERSEY.

I am a little boy seven years old, and have a brother thirteen years old. I like YOUNG PEOPLE. I like "Nan" very much. We have a big tame turtle, but he has buried himself for the winter.

I am just getting over the measles, and thought I would write to you. This is my first letter. ATHELSTANE K.

I am glad you are over the troublesome measles.

DETROIT, MICHIGAN.

I am a little girl eight years old. I like YOUNG PEOPLE very much. I have a sister ten years old, and a baby sister one and a half years old. Jessie, my oldest sister, has a dog named Don; he was a Christmas present. My mamma and papa are going to New York. Jessie and baby and I will be left alone with my aunt Lizzie. I would like to write about pets, but I have none except my baby sister; she is very cunning. I take music lessons, but don't like to practice, and my papa did not know anything about it until I played a piece for him one evening. He was very much surprised. My sister does not know I am writing a letter, and she will not know it until she reads it in the Post-office Box. EDITH L.

Did you not feel rewarded for the trouble of practicing when papa kissed you for that piece,

and called you his dear little persevering daughter, as I am sure he did?

Hudson, New York.

I am a boy almost eight years old. I have a pet dog; his name is Watch. We had two cats come in a bag. One went away because he did not like me; he thought I would hurt him some way. I like to see the boats land at the river, and I have been trying to make one. I made a locomotive the other day. I used a block of wood, and cut it round for the main part, and took eight checkers for wheels, a spool with one end cut off for a smoke-stack, an acorn for the dome, a square block of wood for a cab, and a stiff piece of card-board for the top of the cab, pasted on. For the tender I used two spools and a small paper box. I fastened the spools on the paper box. It looked pretty well when done. My big sister Sue begged it away; she said she wanted it to keep, and would show it to me when I was a man. I like the "Canoe Cruise." I hope my letter isn't too long. OLIVER P.

LEESBURG, FLORIDA.

I am a little girl five years old. I have taken YOUNG PEOPLE all this year, and no one reads it to me, as I can read it all myself. I am a little New York girl, as we only left your city a few weeks ago, and we are all very much pleased with Florida. The climate here is delightful, and we have plenty of bananas, oranges, etc. We see many things that would seem very strange to my little Northern companions, but I suppose if I should attempt to tell about them you would not print my letter. I can not write with pen and ink, but I can write with my papa's type-writer; but it is now broken, and so my papa writes this for me. I suppose it must be very cold in New York now. Isn't it? GRACIE EMERSON M.

You are a clever little maiden if you can write with papa's type-writer when only five years old. Yes, it is cold in New York now, and I am glad you are enjoying yourself in the land of flowers and birds. Still we have good times snow-balling, skating, and sleigh-riding in the winter days, and we don't care for Jack Frost. Do we, children?

EDDIE SHIFFLER.—This dear boy was one of our

most welcome youthful correspondents. He was very fond of YOUNG PEOPLE, and took an interest in all its stories, sketches, and pictures. His sister Nellie, writing from Mansfield, Ohio, tells the Postmistress of the death of her brother in August last. Desiring to earn a little money for himself, he asked his father to let him sell newspapers out of school hours in the railroad depot, where trains were frequently arriving and departing. On the 14th of August Eddie, with his papers, stepped on board a train which he supposed stopped there. Instead, it immediately started at a quick rate of speed, and the little fellow, jumping off, was so terribly injured that he soon died. Nellie's sorrowful letter filled my heart with sympathy, and I am glad to publish here what his teacher wrote of him soon after the sad event. It is a noble record for any boy:

"From his early youth he was never known to speak falsely, and it was always remarked of him that if Eddie said so, it was enough, and could be depended upon. He was generous and open-hearted; often, instead of spending money on himself or his own pleasures, he would delight in buying presents that he thought would please his mother. And although he earned a good deal, for he was industrious, he never wanted to spend money unless it would do somebody some good; he also laid by in bank quite a sum for so small a boy. His father would say to him sometimes that he thought the business was not safe, that he ran a great deal of risk, and that he would rather he would give it up; but Eddie pleaded that he would be careful, and he liked to feel that he was earning money himself, so that as he was known to be careful and thoughtful beyond his years, he was allowed to keep on. It was remarked to his father afterward by one of the officials at the depot, that of all the boys that were constantly on the platform Eddie was the only one who never gave occasion to be reproved. In his daily intercourse with his family, friends, and neighbors he endeared himself by his sweetness of temper and his consideration for others, and to his afflicted mother and father and sister he was a devoted son and brother. To his subscribers he was always prompt and obliging in his dealings, so that his bright, happy face was well known and ever welcome."

Chemistry for the Young.

GODEY'S 1860
(LESSON XIX.—Continued.)

412. This last is a most important experiment, constituting the very foundation of a high branch of chemical analysis, the nature of which we will now investigate by taking a simple case. The expired air of the lungs contains carbonic acid, as we have seen. Supposing we desired to know exactly how much carbonic acid—does it not follow, that by breathing through a weighed quantity of potash solution for a given time, and reweighing the solution after the breathing operation, we should arrive at the knowledge of this quantity? and does it not moreover follow, that this quantity of carbonic acid being known, the quantity of carbon might also be inferred? All this is evident. Suppose, for example, we breathe through a quantity of potash solution known to weigh 1,000 grains, and, after the operation of breathing, we will assume the solution to weigh 1,022 grains. It follows that (supposing the breath to have been dried) 22 grains of carbonic acid will have been evolved, which 22 grains of carbonic acid contain six grains of carbon. To show how simple are the principles on which chemical analysis depends, we will detail the exact steps by which the analysis of the expired air from the lungs may be effected. You will observe that all the principles have already been involved, and that the remarks about to be made chiefly have reference to the form of vessel intended to contain the potash solution.

413. Procure at the philosophical instrument makers the instrument known as the organie



analysis potash bulk and which is of this kind. Dip one end into a solution of liquor potassae, and by suction at the other end fill all three lower or horizontal bulbs, and each of the others partially. Next, by means of



the moisture of the breath by the contents of the tube *xy*, and of all the carbonic acid by the contents of the bulbous tube; any remaining gaseous matter passing will be retained in the glass jar. Should you be in possession of a pair of scales capable of estimating tenths of grains, the tube *xy* and its contents (of known weight), and the potash bulb with its contents (also of known weight), may be weighed again: the increase of the former in weight will be equivalent to the water evolved from the lungs—the increase of the latter in weight small lengths of India-rubber tube (see next paragraph), attach the bulk apparatus at (a) to a glass tube reaching under a glass jar filled with water, and standing over the shelf of the pneumatic trough. On the shelf and under the jar is a little tin pail pan, containing a bit of phosphorus, and raised on a brick; *xy* represents a glass tube, containing small pieces of fused chloride of calcium, a substance greedily attractive of water. The further dispositions of the apparatus will be self-evident. Breathe now very slowly through the apparatus, the

result of which breathing will be the absorption of all will be equivalent to the carbonic acid evolved.

414. India-rubber tubing may be either purchased and cut into the required lengths, or may be made from a piece of sheet India-rubber in the following manner. Take a slip of India-rubber sheet, encircle a glass tube with it, bring both sides of the rubber together, and cut them clean off, close to the tube—thus. The two edges



of the India-rubber will adhere, and the adhesion may be completed by warming the whole before a fire, and pressing the two edges together with the nails.

415. In the preceding experiment the glass jar will contain a mixture of nitrogen and oxygen gases, both in contact with phosphorus. Mark the jar with a file scratch exactly at the level where the water now stands, and put the trough and jar away.

416. Hence it follows that carbonic acid may be removed from atmospheric air, or from hydrogen, or oxygen, or nitrogen (not yet treated of), and from many other gases, by agitating the mixture with lime-water, when carbonate of lime in the form of powder (chalk) will be formed and deposited.

LESSON XX.

Chlorine, Bromine, Iodine, Nitrogen, and their Compounds.

MATERIALS AND APPARATUS REQUIRED.

424. PNEUMATIC-TROUGH, or any convenient substitute; glass jar; pail pan, phosphorus, and hot wire; lime-water; liquor potassae; bromine; iodine; tapers affixed to wires; nitrate of ammonia; copper shreds or turnings; test-tubes; nitric acid; mixture of equal weights common salt and black oxide of manganese; oil of vitriol, spirit-lamp, flask, and bent tube (see 115).

GODEY'S LADY'S BOOK AND MAGAZINE 1860

AN EDITOR'S TROUBLES.

A BROTHER editor from that vast region the West, has written us such a pitiful letter on the subject of an editor's difficulties that we insert it for the benefit of our readers. He writes:—

H—, Sept. 14, 1860.

MY DEAR FRIEND: For I am sure, after you have perused my letter, you will let me call you friend, or even brother, so nearly does my lamentable experience resemble yours. I have just found time, in the midst of my duties, to read the second number of "Scene in Our Sanctum." I read it all, and I can only say that, remarkable as some of the specimens of literature given there are, in every way, I can take from the drawer now open beside me articles sent, actually sent to me for publication, and letters directed to your humble servant, which are fully equal to anything you perused on that hot day. Hot! Some of the letters I have received and some of the articles sent to me would make an editor perspire in December, with the snow two feet deep, and the fire in his office entirely extinct. But enough of this prelude; let me dip into the above-mentioned drawer and send you a copy of what I find there.

Poetry! Mr. Godey, it is my firm belief that every idiot in the United States writes, at some period of his or her life, poetry, and sends it to an editor. Otherwise where does such trash as the following come from? I won't tell you who wrote it, but if an elderly, tall, lank, tallow-haired maiden lady who haunts my office, sends me any more I will publish it, and put her real name to it. There!

Home.

When o'er the vast, expansive firmament we roam,
Cohesive sentiments attract our longing hearts to home.
Home! the synonym of all things blest,
When we by Pandemoniac sorrows are oppressed.

Be it a desert—a vast plain—a scene
Of wildest desolation, still I ween
Each sympathetic breast echoes my cry
In Home's enchanting environs let me live and die!

I won't tell you who wrote it *this time*, but if any more pink-edged notes signed "Aurelia," come to me, let her beware!

Another dip into the drawer produces the following:—

Annabel.

Grace Alice/Laura B—.

ACCOMPANY me, reader, to a stately city mansion where, in the lap of luxury, surrounded by all the costly appendages of wealth, cradled in the sunshine of prosperity, rich, courted, flattered, the idol of society, the star of fashion, shielded from every rough wind, bosomed in ease and comfort, lived my heroine. There let us leave her to seek another scene, the haunt of vice and poverty, the home—alas, to call so low a dwelling by so sweet a name!—the home of Marcus—Marcus! Hark! do you

hear the low silvery tuneful voice that echoes the name?

Radiant in loveliness, in a dark blue velvet and diamonds, she forms a striking contrast to the tall, embrowned son of poverty who stands in the doorway.

"Marcus!"

"Annabel!"

She fainted! He caught her in his arms! She revives! speaks!

"Marcus! my own! we must fly! My father will never consent!"

"Won't he?"

"Never!"

"We will fly!"

They flew!

In a shaded cottage, shut out from the rude world they dwell—loving and loved.

There, for a regular jumble, I think that cannot be surpassed.

Here is something that must touch your editorial feelings. I found it upon my table last week:—

DEAR SIR: I see by your prospectus that your circulation is fifty thousand. Now, sir, that must bring you in considerable money. What is money? Filthy lucre! trash! yet, applied to good purposes, treasure and riches! Therefore apply it to the best use! We are in debt twenty-five hundred dollars for building our church! Pay this! Put your money to the highest use, the diffusion of Christianity. Pay our church debt, and keep your heart from sinful coveting of riches!

Yours in brotherly love, SIMON G—.

Comment is useless! As we are on the letter question, I send another specimen of this favorite torment of editors:—

DEAR SIR: I am the mother of 4 children. Tha are good children, awl of them, too girls and too boys. James, the eldest, helps his pa on the farrum, and is ekwel to a man his pa sez; they are real nice children. Jewlia is one of the hansumest girls ever was, tho I say it as shoodn't; but wat I want principally to rite about is Ellinore, she 's the yungist, and she 's a genius; she is, really. Such ritin as she does, and she only ateteen. I want to see her in print, so I send sum of her poytry to you to put in your paper. If you think ten dollars is too much for it, we 'll say ate.

Yours respectfully, JANE SMITH.

And here is the *poetry*:—

My Kitten.

Mr kitten, how you frisk and play,
All in the sun on a summer's day;
Don't its rays dazzle your eyes,
And make you see stars in the skies?
Kitten! idol of my soul,
Drink the milk in this here bowl;
James says you are a feline beast,

And I have a feelin' heart at least,
Kitten! kitten! I love thee!
Say, kitten, do you love me?

The next I find is poetry. O Jupiter! I shall certainly die of a poetry indigestion

Country Felicity!

EMBROWNED in a mossy nook,
Far from the city's noise,
By rivulet and running brook
I taste the country's joys.
Verdant verdure, grassy green,
Encounters here my eye;
Azure blue, cerulean hue
Hovers in the sky.
Melodious, tuneful melody
Falls on my listening ear;
Harmonious, sweetest harmony
Softly greets me here.
I watch the tuneful nightingale—
The clarion of the night,
And as he soareth heavenward,
I join him in his flight.
Felicity and happiness
Dwell in a country home;
Who from these bowers of endless peace
Could to a city's horrid turmoil roam?

The next package in the drawer was sent to me by a gentleman who resides in H—. He modestly calls them "Imitations of the Poets," and on the strength of this uses great names with a perfect looseness. I give a few specimens:—

Crash! Smash! Dash!

After Tennyson.

CRASH! smash! dash!
O'er thy iron track, O cars!
And I would that my pen could write out
The sound of thy many jars!
Oh, well for the men who travel,
If their nerves are insured to riot!
Oh, well for the grim conductors
That they care not for peace or quiet!
For the noisy trains whirl on
To their stations in country and town;
But oh, when there comes a smash up,
How railway stock goes down!
Smash! crash! dash!
Locomotive and tender and train,
For the ancient days of the old stage coach
Can never come back again.

The Sailor Boy.

After O. W. Holmes.

A SAILOR stood upon the deck,
A handsome lad was he,
But his face was very dolorous
As he gazed upon the sea.
Upon the briny ocean
This boy was forced to roam,
For the very simple reason
That he had no other home.
He likewise had no pa nor ma,
No sister nor no brother;
But this sailor had a sweetheart,
Who loved him and no other.
She was a very lovely gal,
Her Christian name was Sue;
Her ebony hair had a natural curl,
And her azure eyes was blue.

Her cheek was like the blushing rose
That's newly blown in May;
Her teeth were like the costly pearl
That's dived for in the bay.

Now when this sailor left his gal,
To go upon the sea,
She up and concluded she wouldn't stay
Alone by herself. Not she!
She'd heard that sailors always have
A sweetheart in each port,
And she thought to have one true sweetheart
Was all that one man ought.

So she joined her gallant lover's crew,
To sail with Captain Duttons,
And bought herself a jacket blue,
With gooses on the buttons!

But as this sailor stood on deck,
Lamenting of his dear,
He'd not the least suspicion
That Susan was so near.

"Susan!" he sighed—and at the name
She gave his hand a squeeze,

And softly whispered, in low tones,
"Here I am, Ebenezer!"

He clasped her to his manly breast,
And, gazing on her beauty,
This very lovelorn sailor boy
Forgot his sailor's duty.

Don't blame the youth, for all of us
Forget which way to steer,
Neglect our helm and rudder
When we think on woman dear!

The captain came upon the deck,
And seeing what was jogging,
He ordered this sailor boy
To have an awful flogging.

Then to his heart the sailor boy
Clasped his lovely Sue,
Blubbering, "I cannot bear it!"
She sobbed, "I wouldn't, too!"

Again he kissed her lovely brow,
"Farewell to earth," sobbed he;
And these devoted lovers
Jumped right into the sea.

MORAL.

If you've a girl, keep her at home,
Or else, on land or water,
You'll be a gazing in her eyes
At times when you hadn't oughter.

Hard Times.

After Kingsley.

THREE merchants were riding down into town,
In the passenger cars as the clock struck ten;
Each thought of the notes that were coming due,
And all were very disconsolate men.
For men must work that their wives may dash,
Even if there threatens a business crash
And a dreary impending crisis!

Three ladies sat up in their parlors five,
Discussing the news of the world of "ton,"
And chatting of feathers and flowers and lace,
Wondering if silks would go up or down.
For women will dress for ball-room floors,
And dry goods bills run up by scores
In spite of the coming crisis.

Three failures there were in the morning's news;
Three gloomy men were the lords and masters;
Three women were weeping and wringing their hands,
Each blaming her spouse for the country's disasters.
For women will scold if they cannot dress,
And the loss of fine clothes is a dire distress,
Due to the coming crisis.

The Tippler's Soliloquy.

After Shakespeare (some time).

To drink or not to drink, that is the question:
Whether 'tis better, on the whole, to suffer
The stings and torments of a thirst unsatisfied;
Or to take rum against a sea of cravings,
And by deep drinking end them. To drink, to sleep,
No more; and by a spree to say we end
Thirst, heat, and suffering—and all other shocks
That flesh is heir to; 'tis a consummation
Devoutly to be wished! To drink, to sleep,
To sleep! Perchance to dream; ay, there's the rub,
For in delirium tremens what may come,
When by the man of poker we're pursued,
Must make us pause. There's the respect
That makes our soberness of so long life;
For who would bear the kicks and knocks of fate,
The summer's heat, the duns of creditors,
The snarls of scolding wife, the baby's squalls,
The insolence of bosses, and the spurns
That ragged merit of policemen takes
When he himself might his elixium seek
In a mint julep. Who would work all day
To groan and sweat under the scorching sun;
But that the dread of something after drink—
The excruciating headache, after which
A feller's so used up, puzzles the will
And makes us rather bear the thirst we have
Than fly to hiccups and the soda water.
Thus conscience doth make cowards of us all;
And thus the native thirst for brandy toddy
Is quenched with dread of headaches and policemen;
And rarest frolics that are sorely tempting,
With this regard become the direst folly,
And lose the very name of "jolly benders."

What do you think of the proposition contained in the following letter?

DEAR SIR: I am a yung Lady who have Got a good English Education, but no accomplishments much, and I am anxious to improve my talents. I know I've got talents and could write if I was larned a little more. As I can't afford to pay my skoolin myself, and pa says he's paid enuf for my Education, I thought I would Write to You and borrow five hundred Dollars, three hundred for Skoolin, and the rest for Currant expences Which is numerous in a city bordin Skool. I say borrow, for as soon as I finish I am Going to be an Orthoriss and write, and I will write for You and Pay up. Please write immediately, For I want to Get away from this old farm and go to Skool awful.

Yours trewly, ANN R—.

May she live till she gets it—as the Irishman said when the man, paying him a shilling for holding his horse, said—"Pat, you owe me sixpence" "May your honor live till you get it!"

Can anything—I put it to you as an editor—can anything surpass the refreshing impudence of young aspirants to public notice. Read the following:—

DEAR SIR: We are two sisters who are unexpectedly obliged to earn our own support. We have decided to adopt literature for a profession, and have accordingly written a sketch for your paper. Please send \$25 by return of mail, as we are in immediate want of the money.

DORA AND CORA DODD.

Another letter, the exact copy of this, came the same day, and with them were the following "sketches," offered at the moderate price of \$25 each.

Winter.

Cora Dodd.

CONDENSED frigidity diffuses itself over the

surface of creation. Hilarious skaters wake the echoes with jubilant chorus, while through atmospheric space ring forth the sonorous sleigh-bells. Phosphorescent resplendent icicles form glittering substitutes for summer's verdant foliage. Silvery puresnow fluviates mutely from the azure firmament, imbedding vegetation in its chilly folds. Ruddy lambent flames within contrast with frigid hoariness without. Such is winter.

Eternity.

Dora Dodd.

SPACELESS space, unbounded bounds,
Exaggerated length of time,
Never ending, classless rounds,
Forward reaching, endless time
Magnified, all glorious space
Lengthened, coming time
Boundless and unceasing grace
Grant us at that time.

The next letter from the drawer is as follows:—

DEAR SIR: Send me ten dollars four the inclosed poytry, and oblige Yours J. J.

The Slayin Party.

We krammed into a normus slay,
All for to go a slayin;
Fortin kupples we maid that day,
All for to go a slayin.
The nite before the sno had snu,
As if two malk gud slayin,
So I invited lovely Sue
To go with us a slayin.
Twas jolly fun, we all were gal
Wen startin out a slayin,
The sun shin was as brite as May
The day we went a slayin.
We all upset inter the sno
Wen we went out a slayin;
We larfed and skrambled out again,
To finish up our slayin.
Wen we cum home the moon had set,
The day it was a dornin,
We singed alowd, a merry crowd,
We won't go home till morning.
And that is all I now kaa rite
About this famuss slayin,
And so I bid you all good-nite,
And hope you'll go a slayin.

Ain't that enough?

I cannot send you the whole contents of the drawer, for it would occupy all my time for a month, and take all the paper in my office. These few specimens must convince you that you are not the only man who groans at the sight of an envelop, or faints at the prospect of a manuscript. Hoping that I have not bored you, I am Your brother in affliction,

L. C. R—.

MISS PRYMM ON BABIES.

GODEY'S 1872

BY WINNIE.

OF all created human critters, said Miss Priscilla Prymm, emphatically, I ~~despise~~ despise a baby! I used to reckon a snake about the most hateful; but a body knows in ginerall where to look for snakes, and how to keep clear of 'em, whereas there's no gitting out of the way of a baby. Go where you will, in town or country, on land or sea, you find the pestiferous little

critters; and as for street cars and steamboats, a body 'd think they were made for their special accommodation. If I was a railroad president, or a steamboat company, I'd have "babies" as well as "ladies" cars; and the wonder to me is that it hasn't been done before this; 'twould pay, sure.

The first thing a baby does is to holler, and it hollers till it's old enough to use its hands and feet as well as its voice, and then the mischief it does do is beyond calculation. Why, I've had my ink-bottle upset on my new list carpet, and my best chany tea set, with the yaller rosebuds on 'em, knocked off the table—leastways a plate and two cups; and my "Book of Beautiful Extracts" (that was given me by Portifield Grubbs before he took to keepin' company with that bold minx Arathusy Willson) torn to atoms a'most. And all by a baby, or leastwise by a variety of 'em, for they're all alike as a basket of peas. And what's most agravatin' of all is the foolish mothers excusin' the "little darlin's," on the score of "cuttin' their teeth," or "being so remarkably precocious," or something else equally interesting. I've always noticed that whatever badness a baby is guilty of, it's always set down by its

mother to either its teeth or its smartness.

I wonder what the worrying little varmint is made for, and why nature couldn't hev sent folks into the world ready grown up, or at least old enough to be of some use. Now, of what earthly use is a baby, I should like to know? A little shapeless lump of flesh and blood, with its bald head lolloping on one side, and its two goggle eyes staring straight at nothing, and its flabby fists catching at everything in its way, crying at everything sensible and grinning at everything foolish. And what nonsense mothers dew talk to their babies! Why, 'twas only just now I heard Mrs. Simmons, next door, chattering on the back stoop to that bald-headed monkey of hers. "Mudder's own darlin' itty piggy-wiggy! Is he hoongry? Den he sall hab one tacker for eaty. One nicey-ticey itty tacker for mudder's itty precious plum-pie, apple-dumpling, sugar-tandy baby!" Pah! it's enough to make a body sick, and I, for one, don't wonder that children are so long in learning to talk plainly, with such outlandish gibberish ding-donged into their ears day and night! To my mind it's more barbarous than French or Injun.

And the ridic'ulous way in which some folks

dew dress their babies! All smothered up in satin, and feathers, and laces, and furs, for all the world like a milliner's figger-head. I declare to goodness that I sometimes feel a sort of pity for 'em, jest as when I see a organ-grinder's monkey sewed up in a millitary coat and trowsers, with a wooden sword by his side, showing off to a grinning crowd in the streets; and which of the two is most laffable I'm sure it's hard to tell.

"Innocents," indeed! Jest as if they don't know the badness they're about, and don't mean to dew it! Why, I've seen 'em kick, and screech, and bite, and scratch, and pull people's hair like young grizzlies; and to this day you can't convince me that Miss Jones's baby didn't mean it when the little wretch grabbed hold of my new curls as I was putendin' to kiss it afore Deacon Peabody (the week after poor, dear Miss Peabody departed this life, it was), and pulled the hull on 'em right off afore his face, comb and all! If it hadn't a'been for that I might hev—but, ahem! All that I can now say is that I'm truly rej'iced I'm not likely to be pestered out of my life with one of the ugly, dirty, good-for-nothin' little varmint. Of all the troubles and trials of this mortal state and vale of tears, deliver me from a baby!

Lady's Book and Magazine.

PHILADELPHIA JUNE, 1861.

THE MANUFACTURE OF GUNPOWDER.

We should never advise any one, who is not called by duty, to visit a Powder Factory, for, firstly, you run a risk of being blown to nothing; and, secondly, you increase the danger in which the workmen are placed. So, to save you, reader, from these dangers, and to give you a clear account of the various processes that are gone through to produce this important element of war, we sit down to write. As we enter the gates we observe nothing very particular, and our guide seems to be used to all matters connected with the business, so we go gently on until we reach several large stacks of wood, alder and willow, which are standing there to be dried by the atmosphere, previous to being converted into Charcoal. Each piece of wood is about three feet in length, and the manner of burning is as follows: A series of iron cylinders, each about two feet six inches in diameter and five feet in length, are ranged in a building known as the cylinder house. Each of the cylinders is set in brick-work, so arranged that the hot air from the furnace plays quite round it, causing the heat on the upper and under sides to be uniform. Made to fit these cylinders are others of thinner iron and lighter make, capable of being drawn in or out at pleasure. In this portable cylinder, technically called a slip, the wood is put, and then pushed into the fixed cylinder and shut in by air-tight iron doors, or doors made airtight by means of sand. As soon as the action of carbonization commences, all the gaseous products of the wood are expelled through a hole at the back of the cylinder, and thence into the flues, where they are burnt. Here is a twofold benefit. The gases

are almost sufficient to convert the wood into charcoal, and the great nuisance which would be caused by their escape into the atmosphere is avoided. After remaining in these cylinders at a low red heat for about six hours, the wood is perfectly carbonized. It is then allowed to cool; and when drawn out is charcoal of the purest quality, and is ready for grinding. This process is none other than that of grinding coffee. The charcoal is put into a hopper, from which it falls into the mill, is cut or crushed to pieces, passed through a reel covered with a canvas of the finest mesh, and is then fit to perform its part in the manufacture of gunpowder.

Sulphur is prepared by heating a quantity of crude sulphur in an iron pot, conducting the vapors into cool chambers, where they fall as a very fine powder, called flowers of sulphur. When the chamber becomes warm these flowers of sulphur melt, and run into cylindrical moulds, in which form the sulphur is called roll sulphur, and is quite pure. It is then ground and passed through a very fine sieve, when it also stands ready.

The last and most important ingredient is Nitre, or, as it is more commonly called, saltpetre. This is obtained chiefly from Bengal, and in its crude or "grough" state contains from one to twenty per cent. of impurities; common salt being the chief. In this state then it arrives, and before being used has to be freed from every impurity. This used to be done by repeated boilings and crystallizations; but now it is boiled once and passed (in a fluid state) into large shallow copper pans, called

coolers. Now if allowed to cool at rest it forms itself into large crystals, which contain much that is impure; but if you can get the crystals small, there is little impurity to be found. This is obtained by keeping the liquid constantly in motion during the cooling process; so that the nitre crystallizes in very small particles, so small indeed that the saltpetre thus crystallized is called saltpetre flour, and is, if carefully washed with distilled water, absolutely pure, and so fine that no grinding is necessary. Under the old system the saltpetre had to be thrice boiled, thrice set to cool in crystallizing pans, and then melted, run into moulds, cooled, and ground. We are indebted to the French for the new process.

After having then seen our ingredients carefully prepared, we now bring them together in a "house," called the "mixing house." They are here weighed in the following proportions:—

Saltpetre	75	per cent.
Sulphur	10	" "
Charcoal	15	" "

These ingredients are then placed in the mixing machine, which is simply a wooden box, through which a shaft passes armed with long copper or gun-metal teeth. The shaft is made to turn on its axis very rapidly, and by means of the teeth the mass is intimately mixed. A bag is placed under the machine, a slide is withdrawn from the bottom, and the powder (for such it is now, but very weak) falls into the bag. The quantity placed in one bag is called a charge, and weighs between forty and fifty pounds. The charge (*green charge* called

generally) is now ready for the incorporating mills, where the several ingredients, which before were only mixed, are now incorporated, or very intimately combined, by means of a heavy grinding pressure. Imagine a large round dish of iron. In the centre of the dish is an upright shaft, made to turn by means of gear-work underneath the floor; on this dish are placed two wheels, called runners, made of iron or stone, each weighing three or four tons. Through the centre of each runner a horizontal spindle passes, which spindle also passes through the upright shaft before mentioned, cutting it at right angles. When the upright shaft is put in motion of course it carries round these runners, which perform about ten revolutions per minute. The weight of the runners causes great pressure upon the powder, which is spread equally over the bottom of the dish, and the small circle in which the runners revolve causes the grinding, by which means, and the aid of water, the intimate mechanical combination of the ingredients, upon which the strength of the powder entirely depends, is obtained. The time necessary to bring the powder to its proper strength varies from one hour to ten, according to the quality required. One manufacturer has patented a process by which he causes the bottom of the dish to be heated, by which means he obtains the required strength in a much shorter time. When taken from these mills it is in broken cakes of a grayish color, and about half an inch in thickness. It is now called mill-cake, and has attained its greatest strength—all after processes decreasing its explosive force, but increasing its durability.

From the incorporating mills it is taken to the *press house*, where the mill-cake is passed between cylindrical toothed rollers, which in motion turn towards each other, and crush the powder again to dust. On one side of this press house you see a large cubical box placed between four iron columns, which support a huge cross-bar of iron, called a cap; underneath the cap is suspended a cube of wood to fit the box which stands below. The powder, when broken down, is carried to this box, on the bottom of which a layer of it is placed. This layer of powder is covered with a sheet of copper, and on the copper is placed another layer of powder, then another sheet of copper, and so on, alternately a layer of powder and a sheet of copper, until the box is full. A man then turns a small cock, the box begins to rise, and pushes itself against the piece of wood suspended beneath the cap. As this wood fits the box, the box keeps rising, but as it rises the powder is compressed to the requisite hardness. But how is the box made to rise? By hydraulic pressure. The box stands upon the ram, as it is called; this ram fits into an iron cylinder; into the cylinder water is forced, which raises the ram and of course the box placed upon it. The pressure obtained is generally about four tons to the square inch upon the ram. When the pressure is taken off, and the box opened, the powder and copper are compressed into one solid mass; but a few hard blows with a wooden mallet soon cause the cakes to separate. The copper

plates are put aside for future use; the cakes of powder, about two feet six inches square and one-eighth of an inch in thickness, are carried to the breaking-down machine, where they are again passed between the toothed rollers and broken into pieces hard and black, of irregular forms, varying from an inch and a half to half an inch in length. The powder is now fit for granulating or corning, as it is called. Before we leave this house we may just get a glimpse at the men here, and yet the men you cannot see, only their intensely black faces and lively eyes. Strong men and true, no doubt, to their employers, but not always conscious that while careful for "the master," they are caring for their own lives.

We take leave of the press house, then, and follow the hard pieces of powder to the granulating house. Here we are in great danger, and not very well able to see it on account of the "dust" flying about. However, we can perceive the "house" is tolerably full of machinery; consisting principally of the toothed cylindrical rolls and "Jacob's Ladders." These "Jacobs" are endless straps passing over wooden wheels; each strap has a number of cups fixed upon it. The powder is "shot" into a hopper on the floor; at the bottom of this hopper one of the wooden wheels rotates, and over it the endless strap passes. In the downward journey the cup is inverted, but no sooner does it get its turn on the bottom wheel that it rights itself, and not only so, but fills itself with powder, which it carefully carries to the housetop, and as it turns on the upper wheel shoots its load headforemost into another hopper, from which it passes between the rollers, and is crushed into the required sized grain. So these "Jacobs" save the trouble and expense of having men to carry up the powder on their backs. The powder here is not only granulated, but a large portion of the dust is taken from it and returned to the incorporating mills.

We have now the powder in grains of various sizes and of a very dull grayish brown color, not much like the powder of commerce. But we shall get it so much like that, that you will recognize it wherever you may meet with it. From the granulating house it is carried to the rubbing house, where the powder is placed in cylindrical vessels of wood or canvas, and rapidly turned upon the vessels' axes. By this motion the grains of powder are hardened, and by the attrition they gain a glossy appearance and look bluish-black. This rubbing of the powder is a great deterioration to the explosive quality of the powder; it makes it less angular, but, as a counterbalance, it is much more durable, being less impervious to moisture than before. Well, having whirled it in the cylinders for ten or twelve hours, and having seen it brought out, and noted its different appearance, we follow it to the drying house. Not long since it used to be dried as follows: The powder was spread upon canvas cases and placed in racks round a room, called the *store*; into the wall of this building a huge iron pot was built: not standing on its bottom, but so placed that the bottom of the pot should project

into the room while the mouth was outside. In this a fire was kindled, and the bottom of the pot heated to a red heat. Pleasant, certainly, when one entered to see the round red pot glaring in amongst the powder and threatening death and destruction to all. Now the stove is heated by means of steam pipes passing through it, and the temperature usually obtained is about 130. For twenty hours it rests in this warm climate, during which time it parts with all its moisture except about nine per cent. At this stage the powder is somewhat dusty and of different-sized grains; two things then are required, to clean it from the dust, and to separate the grains into the various sizes, for large or small arms. To accomplish these ends, the powder is transported from the stove to the dusting house.

The dusting house, as its name implies, is the place where the powder is dusted, or finally cleansed from any remaining dust. This is an important affair, as the fouling or not fouling of the gun depends greatly upon this matter. It is generally performed by causing the powder to run through a series of reels covered with open canvas, which reels are rapidly whirled round, and while they are in motion all the very fine powder or dust falls through the canvas. When properly dusted, the different-sized grains have to be separated one from another; the "large grain" for artillery; the "fine grain" for rifles; the "double F." and "treble F." for sporting purposes; and so on. When separated it is carefully weighed, put into barrels, headed up, and carried away to magazines, quite finished and ready for use.

These various processes cannot be carried on without much risk to life and property, hence the necessity that exists for the greatest possible care throughout all departments. Every man has clothes to be used only in the houses, so that there can be no chance of the least particle of grit getting on to the clothes, neither is any man permitted to wear metal buttons. All shoes are exchanged for shoes made only of leather, no nails of any kind; and these are worn only in the houses. In the machinery brass and copper are largely employed, because from them it is almost impossible to strike fire; and to prevent any friction under foot should grit get into the houses, the floors are carefully covered with leather. Still, with all these precautions, accidents are not entirely avoided, though greatly diminished.



Traps for Snails.—Snails are particularly fond of bran; if a little is spread on the ground, and covered over with a few cabbage-leaves or tiles, they will congregate under them in great numbers, and by examining them every morning, and destroying them, their numbers will be materially decreased.

Small Gas Furnace

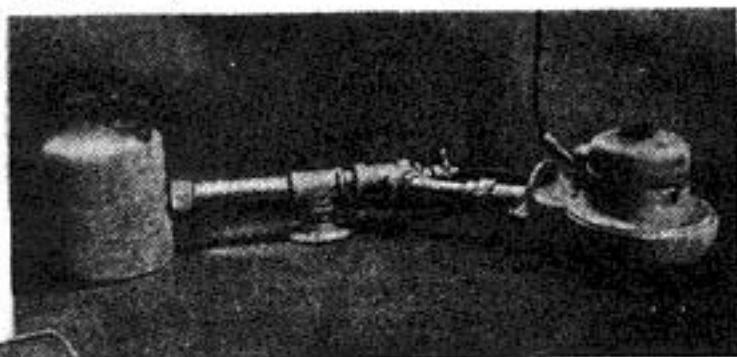
Gives Great Heat for Melting Metals

By
**EVANS W.
BUSKETT**

Popular Science
February 1937



The forms in position for pouring the filling material, which is fire clay and sand, mixed



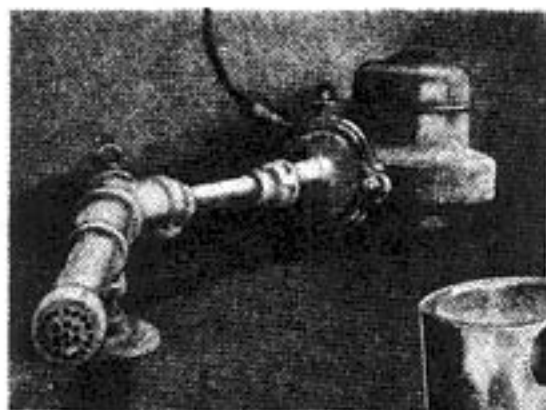
The furnace in use. It melts copper, brass, aluminum, gold, and silver. An old vacuum cleaner supplies air

for assaying lead, and in the preliminary melting for gold and silver assays. It is very durable and should last for years with proper care. Many melts have been made in the original furnace, in one of which the crucible burned through and all of the slag spilled into the furnace. Another crucible boiled over. In spite of this drastic treatment, the furnace is in good condition.

The container of the furnace is made from a can about 7 in. in diameter and the same in height. The inner form is a quart can about 4 in. in diameter and 4½ in. high. Holes for the burner are cut in the large can about 2 in. from the bottom, and in the smaller can, flush with the bottom. A crucible is used as the form for the burner hole. One of the photographs shows the cans and crucible assembled for pouring.

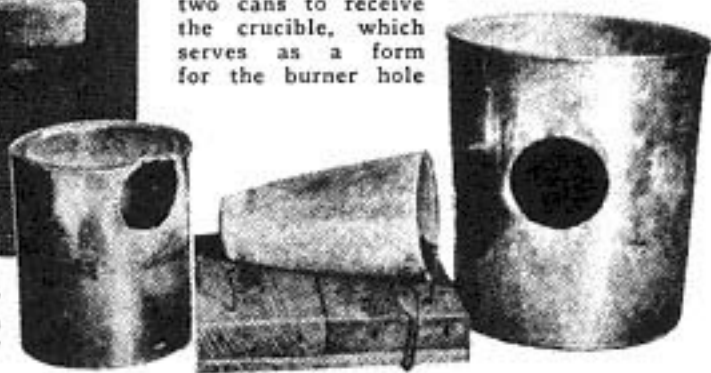
The filler is made of a mixture of equal parts of fire clay and sand; and a tablespoon of salt will improve the binding qualities. A good grade of fire clay should be used. The ingredients are mixed thoroughly while dry, and then made into a thick paste with water. The mixture is put into the forms a little at a time and worked down firmly with a stick. It is not necessary to treat the crucible to prevent its sticking to the clay. It will draw out very easily, and can be broken off and used later as a burner bushing.

To break off the bottom of a crucible, it should perhaps be noted, is quite difficult to do without breaking the crucible in the wrong place. Place the crucible right side up on a heavy, flat piece of iron. Insert a blunt iron rod, hold it squarely on the bottom of the crucible, and strike it a sharp blow with a heavy hammer. There will be few failures by



The burner is made of ordinary pipe fittings and connected with the gas supply and vacuum cleaner

Holes are cut in the two cans to receive the crucible, which serves as a form for the burner hole



using this method. The lower part of the shell can then be trimmed to the proper size with a pair of pliers.

After being filled, the forms should be allowed to set for several days, and then placed in a warm place for a few days longer. On top of a boiler is a good place for the final drying.

Neither can used as a form is removed. The outside can acts as a container and prevents the furnace from falling to pieces in case it cracks. The inside can burns out in a short time, so it is not necessary to remove it. The clay-and-sand walls eventually break down, but it takes a long time because the melting point of the mixture is so high.

At first the burner hole was not bushed, but after the furnace was in use the hole soon burned out to such a size that a bushing was necessary. The bushing, made from the crucible as previously suggested, is fastened in place by a mixture of fire clay and sand. The large part of the crucible is, of course, on the outside.

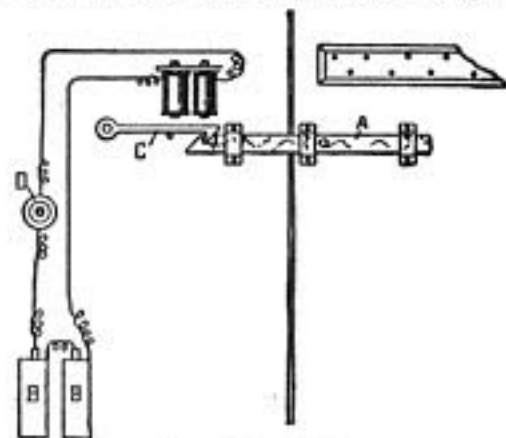
The burner is made from an ensemble of pipe fittings. It consists of a 1-in. cap, a 6-in. long nipple, one T, one close nipple, one floor plate, and one Y. The floorplate and close nipple are filled with lead to add weight. Twenty-five ⅛-in. holes are bored in the cap as shown. The Y is reduced to ½-in., and the side opening is connected with the gas supply by a regulating cock, which is drilled out to ¼ in. The other opening to the Y is connected directly with a blower made by cutting off the superfluous parts of a vacuum cleaner. It has been found that the sizes mentioned, that is, ¼-in. for gas and ½-in. for air, make the proper mixture of air and natural gas for high temperature. Where manufactured gas is used, or the pressure is different, other proportions will have to be worked out experimentally, using the above figures as a starting point.

The intake for air may be made larger, and a valve used to regulate the flow. This was tried with a ½-in. valve, but it cut down the quantity of air so that there was not enough to give maximum efficiency.

An Electric Lock

Popular Mechanics 1913

The details of the construction of an electrically operated lock are shown in the illustration. When the door is closed and the bolt A pushed into posi-



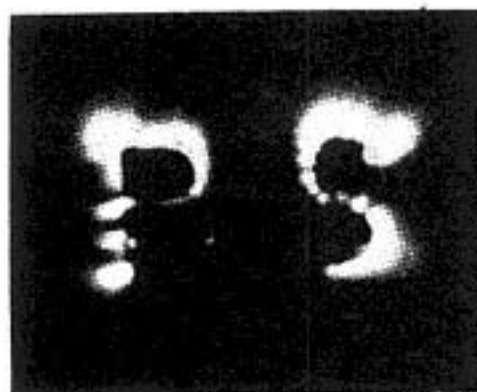
Simple Electric Lock

tion, it automatically locks. To unlock, push the button D, which act will cause the electromagnet to raise the latch C, when the bolt may be drawn and the door opened.

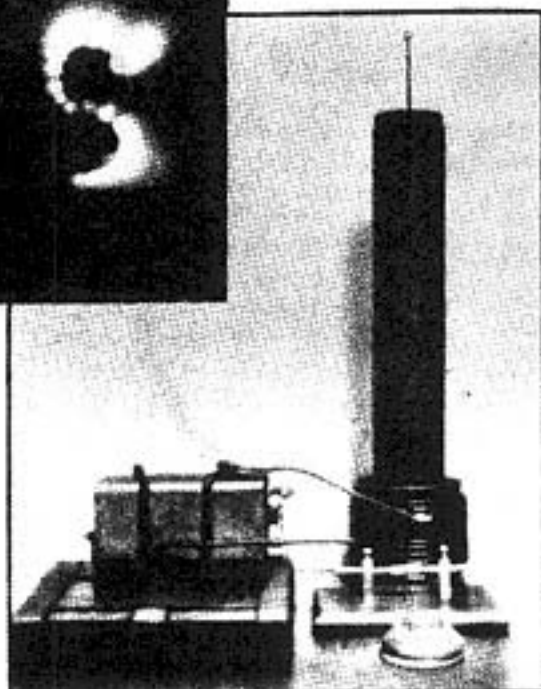
SPECTACULAR

High Frequency

EXPERIMENTS



Two metal letters "P S" giving off a high-voltage discharge obtained by means of the inexpensive outfit illustrated at right



HERE is a high-frequency outfit capable of giving a good 3-in. spark and providing an endless number of weird and interesting experiments, yet it can be built in a few hours time and almost entirely from salvaged materials.

Obtain a mailing tube approximately 2 in. in diameter and 12 in. long. Cut two circular blocks of $\frac{1}{2}$ in. wood to fit into the ends of the tube, and bore a $\frac{1}{4}$ -in. hole through the center of one of the blocks. Glue a short piece of $\frac{1}{4}$ -in. round wooden rod in the center of the latter block and allow it to extend $\frac{1}{2}$ in. from the surface as a dowel. Glue one block in each end of the tube, shellac the tube, and allow it to dry.

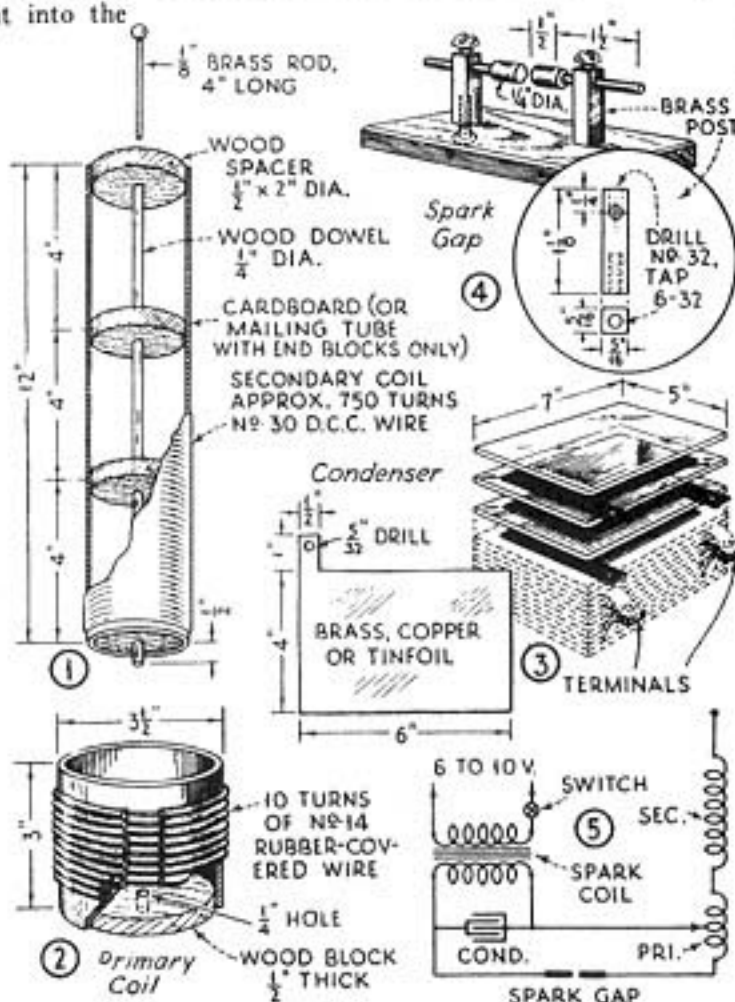
If a mailing tube is not available, a satisfactory substitute may be made by making a form as shown at Fig. 1, wrapping it with several layers of thin cardboard, and securing the end with glue. No nails or screws should be used in the construction of the high-frequency coil.

Wind the cardboard tube to within $\frac{1}{4}$ in. of each end with No. 30 double cotton-covered wire, which will require approximately 350 ft. or a fraction over $\frac{1}{8}$ lb. Insert a $\frac{1}{8}$ -in. brass rod, 4 in. long, in the top end of the coil form, and solder one end of the coil to it. Fasten a small metal ball to the upper end of the rod.

For the primary coil, obtain a cardboard tube 3 in. long and from 3 to 4 in. in diameter. A section of a salt or oatmeal box makes a good

form. Cut a circular block of wood to fit into one end, drill a $\frac{1}{4}$ -in. hole through the center, and glue in place. Wind the form with ten turns of No. 14 rubber-covered wire from which the insulation has been removed for a space of $\frac{1}{2}$ in. on each turn, as shown in Fig. 2. The wire is first wound on the form, the spaces to be bared are marked with a sharp knife, the wire is removed, and the insulation cut away. Secure the wire by removing the insulation from the end and passing the wire through

a small hole in the cardboard form. Insert the extended end of the first-made or secondary coil into the same hole in the bottom of the primary coil, and glue in place. Then solder the lower end of the secondary



How the primary and secondary are wound on cardboard tubes; the condenser and spark gap; and the wiring diagram

*Made with
Aid of Junked
Ignition Coil*

By
KENDALL FORD
Popular Science 1935

coil to the lower end of the primary coil.

For the condenser obtain fourteen pieces of glass, 5 by 7 in. Old photograph plates from which the emulsion has been removed are excellent, but any scrap pieces of glass will do. Cut thirteen pieces of brass, copper, or tinfoil to the size and shape shown in Fig. 3. Drill holes in the tabs at the end of the sheet for connecting screws as shown. In stacking the condenser, place a sheet of glass on a flat surface, then a sheet of foil on the glass, another sheet of glass, then a sheet of foil with the tab at the opposite end. Continue until the condenser is assembled as in Fig. 3. The foil should be placed on the glass so that there is a margin of $\frac{1}{2}$ in. all the way around. Bind the condenser together with friction tape.

The details of the spark gap are shown in Fig. 4. Two brass posts are mounted on a block of well-seasoned wood, and the adjustable electrodes made from pieces of $\frac{1}{4}$ -in. round brass rod soldered to $\frac{1}{8}$ -in. pieces. The latter are held by means of No. 6-32 set screws.

A vibrator type Ford ignition coil will be required to excite the high-frequency coil. One may be obtained from any auto wrecking yard, but make certain that the condenser within the coil is not damaged. If the coil gives a hot spark at least $\frac{1}{2}$ in. long, it will be satisfactory.

The diagram of connections is shown in Fig. 5. The wire from the spark coil to the primary of the high-frequency coil should be flexible and should terminate in a spring clip to enable its being connected at any turn of the primary coil. The spark gap should be separated not more than $1/16$ in. Connect the primary to a transformer or battery of from 6 to 10 volts, and vary the number of primary turns in the circuit until the longest spark is obtained from the discharge ball at the top of the coil. If the coil is operated in semidarkness, the effects are most spectacular, due to the fine corona discharge that surrounds the upper coil but is not visible in a strong light.



YOU CAN
PERFORM

Mystifying Stunts

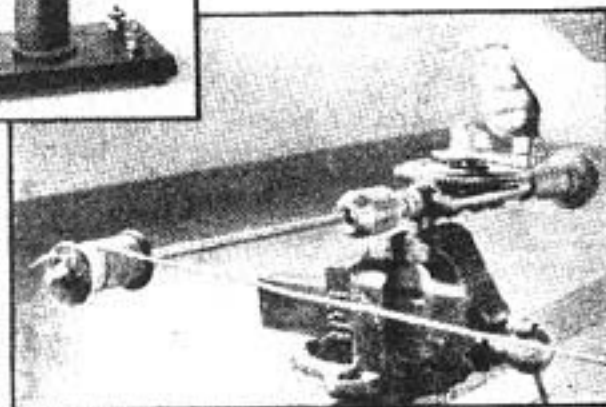
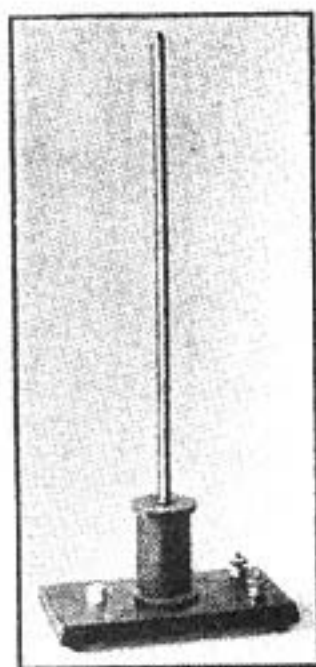
with this homemade

Repulsion Coil

By

Kendall Ford

Popular Science 1933



The completed repulsion coil and an easy method of winding the wire with the aid of a hand drill. The coil may be concealed in a box, if you prefer

ELECTRICAL experimenters who have seen large repulsion coils demonstrated in college or school laboratories have often wished to duplicate the experiments in their own workshops, but have hesitated on account of the expense involved. The repulsion coil to be described, however, may be built for a few cents and will provide no end of interesting and novel experiments.

The coil is connected to a transformer giving from 6 to 10 volts. Then, if an aluminum ring about 5/16 in. in diameter and 1/4 in. wide is placed over the vertical steel rod, it will be expelled over the top with considerable force when the push button is pressed. If the ring is dropped over the rod while the button is being pressed, it will oscillate upward and downward and finally come to rest about halfway up the rod. Placing one pole of a permanent magnet near the ring while it is suspended will cause the ring to rotate rapidly. Reversing the magnet will cause the ring to rotate in the opposite direction. If the coil is boxed in, allowing only the steel rod to protrude, the effects will appear very mystifying to the uninitiated.

The form upon which the coil is wound consists of a piece of fiber tubing 5/8 in. in outside diameter and 1 3/4 in. long. Mount a fiber washer 1 3/8 in. diameter on each end of the fiber tubing. One washer—the outer or lower one—should be drilled for the coil ends to pass through. Thread the end of a 12-in. length of 1/4-in. screw-stock steel a distance of 5/8 in. and screw one hexagon nut into place. Place the coil form over the steel rod and fill the space between the rod and fiber tubing with

pieces of No. 20 gage soft iron wire 1 3/4 in. long. The last few pieces of iron wire should be forced into place in order to secure the form upon the steel rod.

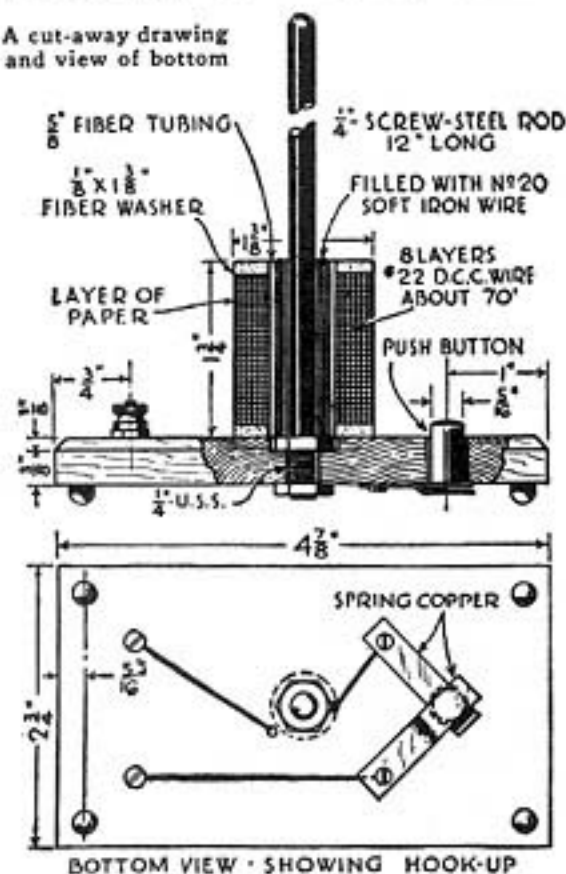
Place the end of a length of No. 22 double cotton covered wire through the inside hole in the washer and wind eight layers upon the form. The winding can be facilitated by placing the rod in the chuck of a hand drill, as shown in one of the photographs. Shellac the coil and cover with a layer of heavy paper to give a finished appearance.

Mount the coil on a wood base as shown in the drawing. It will be necessary to countersink the mounting hole in the wood to provide a space for the hexagon nut next to the coil end. Mount the push button, which consists of two strips of No. 26 gage spring copper and a piece of 5/16-in. dowel, in the approximate position indicated in the drawing. Provide terminal screws and connect up as shown. Place rubber-headed tacks at the corners underneath the base.

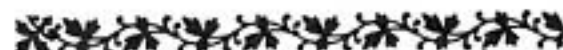
Since the layman generally thinks of an electromagnet as having only the power of attraction, a brief explanation of how the coil operates may be of interest. When an alternating current flows through the winding of the coil, the magnetic field produced flows upward through the core one instant and downward the next. The changing magnetic field flows through the aluminum ring and induces a current in it that is opposite to the current flowing in the coil.

The current flowing in the ring sets up a magnetic field which is, at any instant, opposite to the field produced by the coil winding, consequently the ring is forced away from the end of the coil.

A cut-away drawing and view of bottom



BOTTOM VIEW - SHOWING HOOK-UP

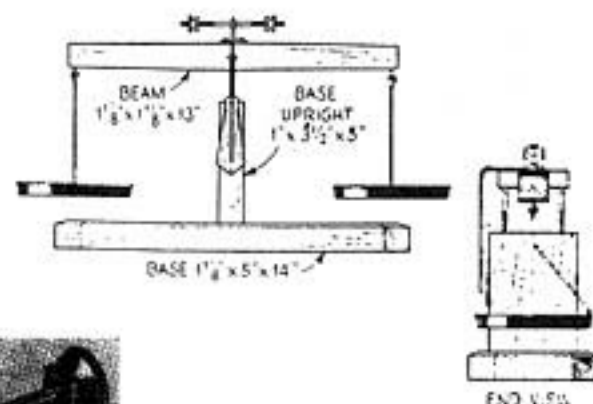


SCALES FOR WEIGHING CHEMICALS BUILT AT TRIFLING COST

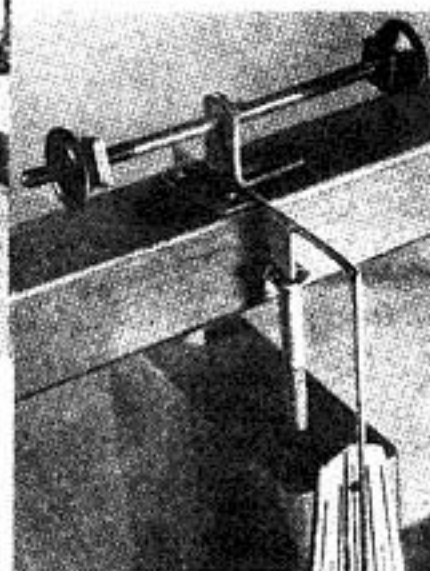
Popular Science Monthly, August 1936



The scales are shown in use at left, and the dimensions are given at right. The weights are cut from sheet aluminum, lead, and copper, and carefully matched with a set borrowed from a druggist or chemist



A brass fulcrum bar is let into the beam, as at the right, and filed and stoned to form chisel-edged bearings



tapered from the middle to the ends. The fulcrum bar, which is let into the beam, is made from a small piece of sheet brass; and the two lower edges, protruding on either side of the beam, are filed and stoned to a cold-chisel type of edge.

The device for adjusting the balance is formed from a 4-in. length of $\frac{1}{8}$ -in. rod, threaded $1\frac{1}{2}$ in. at each end. This is then soldered at its middle point to the small supporting angle through which it passes. In the absence of a suitable tap and die,

simply solder two flatheaded bolts by their heads on each side of the angle bracket. This angle is fastened with two small wood screws on top of the beam. The threaded rod is provided with a nut and lock nut at either end.

The trays were formerly the lids of $\frac{1}{2}$ -lb. tobacco cans, $4\frac{1}{2}$ in. in diameter. The small hooks under the beam for suspending the trays were formed by cutting away a section of two small screw eyes. Before painting the scale, cover the suspension hooks and all other bearing points in order to avoid the additional friction that paint would cause. The indicator is merely another scrap of wire, and the dial a piece of suitably marked Bristol board.

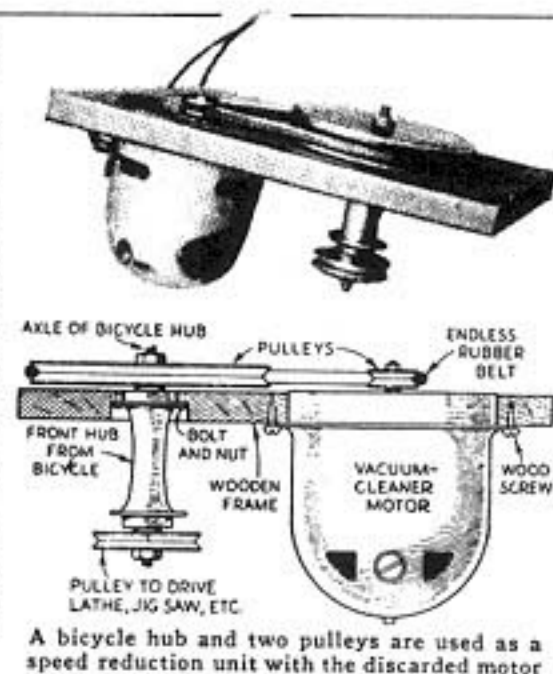
Should the scale be used in a position that is not level, a leveling device must be added.—R. O. L.



VACUUM-CLEANER MOTOR ADAPTED FOR SHOP USE

Popular Science Monthly, November 1936

VACUUM-CLEANER motors are comparatively easy to obtain second hand, but because of their high speed (8,000-10,000 r.p.m.) are not suitable for driving most home workshop machinery without some form of speed reduction. The illustrations show how a countershaft may be added to the motor, making it a compact power unit to be used in place of a regular $\frac{1}{4}$ h.p. motor. The basis is a bicycle front hub, on the axle of which are mounted a large and a small pulley, one at each end. The motor and countershaft are then arranged on a suitable wooden board. The belt may be a round leather one, but a rubber vacuum-cleaner belt will give better results.—CARL FROEN.

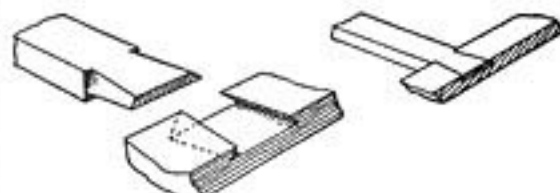


A bicycle hub and two pulleys are used as a speed reduction unit with the discarded motor

A Dovetail Joint

Pop. Mechanics, 1913

The illustration shows an unusual dovetail joint, which, when put together properly is a puzzle. The tenon or tongue of the joint is sloping on three surfaces and the mortise is cut sloping to match. The bottom surface of the mortise is the same width at



Shape of Tenon and Mortise

both ends, the top being tapering toward the base of the tongue.

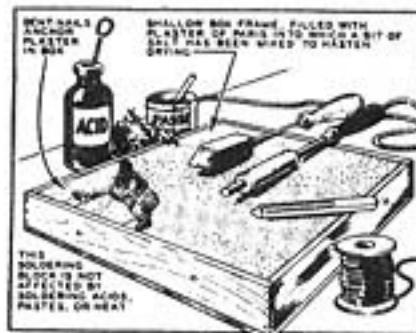
WATER, to Soften.—Wood ashes form a good lye for softening water, but care must be taken that they should be all wood.



Soldering Block Resists Heat and Acid

IDEAL for soldering is this little plaster of Paris block which keeps your workbench free from acid burns and charred spots. Consulting the drawing at the right, you will see how the trick is turned.

A frame of wood, not very deep, is filled with plaster of Paris, with which salt has been mixed for quick drying. On this block you can solder any job that turns up, and the acid won't have the slightest effect. Likewise with the heat of the iron.—James Flug.



Vacuum-Cleaner Motor Runs BLOWPIPE

Popular Science 1937



WHERE electricity and city gas are available, a soldering and annealing torch for metal craftwork can be made from an old vacuum-cleaner motor and a hand blowpipe of the comparatively inexpensive type sold by dealers in decorative metal-working supplies.

Remove the motor from its frame and mount it on the bench, on a shelf or bracket under the bench, or on a separate baseboard, as most convenient. A separate baseboard is best if the apparatus is to be moved about.

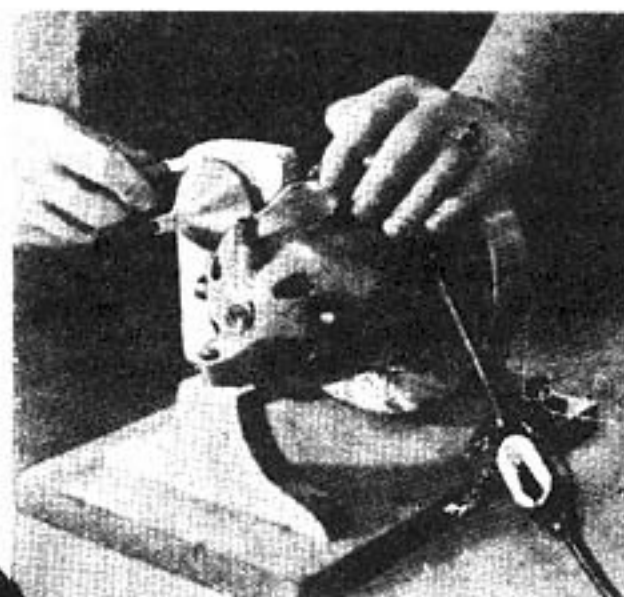
Take off the connection that goes to the dust bag, and in its place put a piece of wood, using a gasket compound between the wood and the metal to prevent air leaks. Attach a small funnel, as shown, over a hole bored through the board. Use tacks and cement around the edges.

The gas may be con-

trolled with the hand blowpipe, which has a built-in valve. The easiest way to control the air is by regulating the speed of the motor, and this is done with a foot rheostat. If a rheostat is not available, use an air valve controlled by a foot pedal.

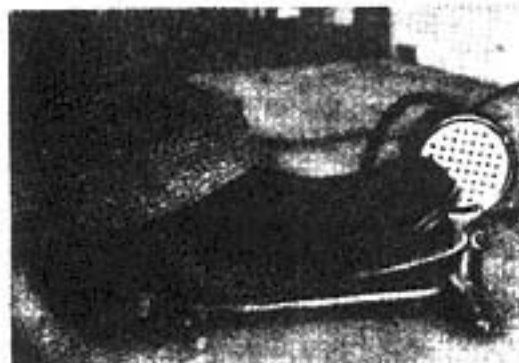
The air valve shown in the circle below was a discarded one originally used to operate twin air horns on an auto. In this case the air hose was cut in two and the ends connected with the valve. As the extra outlet was not needed, it was plugged.

The foot pedal is easier to operate if a spring is placed underneath. The spring shown with the pedal is a common spring clamp.—W. T. BAXTER.



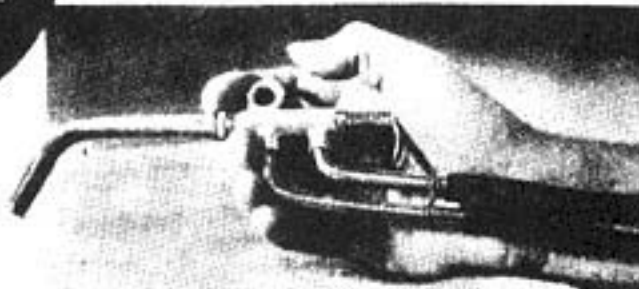
How to mount the vacuum-cleaner blower. The dust connection is replaced by a piece of wood to which a small funnel is attached

Using the blowpipe to anneal a copper bowl. Asbestos board protects the bench top from the heat



A foot rheostat controls the speed of the motor and thus regulates the volume of air

Right, a salvaged air valve serves when a rheostat cannot be obtained. It is operated by using a pedal



This is a type of hand blowpipe commonly used. It has a built-in valve for regulating the flow of gas

Measuring Temperatures

IN A WORKSHOP FURNACE

W. C. CHENEY tells how to make a pyrometer and gives hints on tempering

Popular Science, December 1936

GUESSWORK in the use of a furnace for hardening and tempering steel can be eliminated by means of a pyrometer, which is nothing more than an instrument for measuring heat beyond the range of an ordinary thermometer. In industrial plants and large shops, pyrometers are, of course, standard equipment, but many small shops still depend upon hit-and-miss methods of determining furnace temperatures. This is unnecessary because a serviceable instrument can be assembled at relatively small cost.

The pyrometer illustrated was designed for a furnace described previously (See Pages 495 and 515). It would be an equally valuable accessory for any similar type of heat-treating furnace.

The sensitive element of the pyrometer is made of two dissimilar metals that will withstand high temperatures and generate an electric current when heated. There are a number of these alloys, and they may be obtained from various instrument companies for a few cents, or the complete element with lead wires attached can be bought for approximately three dollars.

Lay the alloy wires side by side and weld together at one end with the acetylene torch. Twist them and weld copper wire leads to the two open ends. Into one end of a 1/2-in. black iron pipe about 10 in. long, insert a porcelain tube such as is used in house wiring. The tube may be ground to size on an ordinary wheel if too large. Insulate the alloy wires and the lead wires with thin sheet asbestos. If the element is a homemade one, the lead wires should not be over 2 ft. long.

The lead wires are connected directly to a millivoltmeter, but as the element has polarity the same as a battery, the leads may have to be switched. This can be found by trial. When the element is used in the furnace, care should be taken to see that the alloy wires do not come in contact with the object being heated.

Because the current generated by the element is proportional to the heat applied, all that is necessary to obtain the temperature reading is to melt several metals of known melting points and use these temperatures to lay out the scale on the meter.

The meter may be any millivoltmeter, obtainable at a radio service shop or from a mail-order radio supply store for a few dollars. The percentage of error in the cheaper instruments is not sufficient to cause difficulty so there is no object in buying an expensive one. The meter illustrated was purchased for \$1.50 and the error, when checked by eye with a \$30 instrument, could not be noticed.

Remove the cover glass and glue a piece of white paper to the meter's face. Take various temperatures and mark each reading on the paper with a pin prick. Average the temperatures and distances of pointer travel, and step off the scale with a pair of dividers. In the particular case described, the pointer moved approximately 1/4 in. for each 150 deg. of temperature rise. The scale was laid off from 0 to 1,800 deg. and when checked with a standard instrument, showed only a 2-percent error.

To obtain these temperatures begin with the furnace cold. Place a pan of water inside and start the torch. Bring the heat up slowly until the water just starts to boil. Place the element in the water and take the first reading on the dial, which will correspond to 212 deg. F. at sea level. Next take a piece of brick and hollow it out. In the hollow place a small quantity of zinc, put the element close to the metal, and raise the temperature until the zinc melts, which will give the reading for 788 deg. Do the same with a piece of aluminum, and the reading will be for 1,220 deg. Average the temperatures and swing of the pointer in order to extend the readings to 1,800 deg.

Once the pyrometer has been calibrated, the furnace can be adjusted to hold any required temperature. Information on heat treating steel, the use of baths for drawing temper, and

An inexpensive millivoltmeter calibrated so as to give reading of pyrometer immediately in degrees Fahrenheit



tables showing tempering data for various tools can be found in standard shop handbooks. For the purposes of this article it will be sufficient to describe one of the simplest possible ways of tempering two common types of tools—cold chisels and wood chisels.

Chisels must be made of steel which is hard, fine-grained, and tough. To obtain maximum fine grain with maximum hardness, the steel must be quenched at just the right temperature, which for the average run of shop tool steel is between 1,450 and 1,500 deg. F. This gives the finest grain, but the tool is too hard for practical use, so some of the hardness is withdrawn by tempering—applying

a low heat gradually and again quenching at the proper moment.

Cold chisels, after the first quenching, should be scraped or ground bright. Place in the furnace, leaving the door open, and have at least one third of the cutting edge in the open. In a few minutes colors will appear and slowly travel toward the edge. When the edge is a dark purple, quench the tool in cold water. Instead of watching the colors, one may try the edge with a sharp file and quench when the file starts to take hold or cut.

The same procedure is used for wood chisels except that the tool is quenched at a dark straw color.

If a large number of similar articles are to be treated, the best way is to harden them and then cool the furnace to the proper temperature, found by trial, and note the reading on the pyrometer, setting the burner to hold that heat. Extreme care should be taken in tempering or the tools will not stand up.

Some points worth remembering are:

If in doubt about a piece of steel, harden a sample first.

When practical, obtain the temperature data of the steel from the maker.

Never leave the shank of a chisel hard. Not only will it spoil the head of the hammer, but it is apt to chip and drive splinters into your hands and eyes.

When quenching a tool, plunge it straight down in clean cold water and hold it in one position until it is cold. Don't move it around.

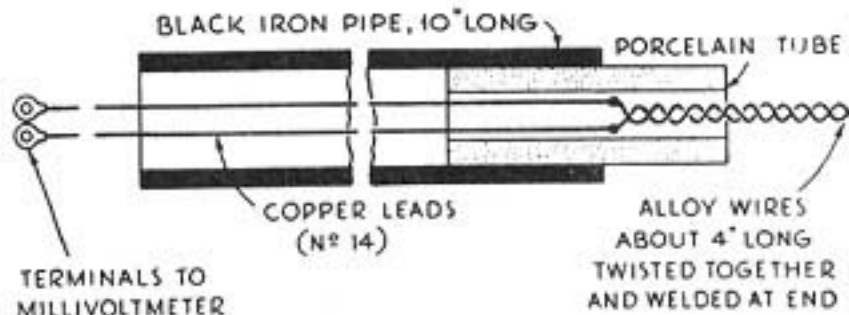
If you overheat a piece of steel, don't cool to the critical temperature and then quench. Allow the steel to cool slowly in sand or slaked lime and when cold, reheat to proper temperature.

If you wish to cool a piece of tool steel without hardening, quench in soapy water.

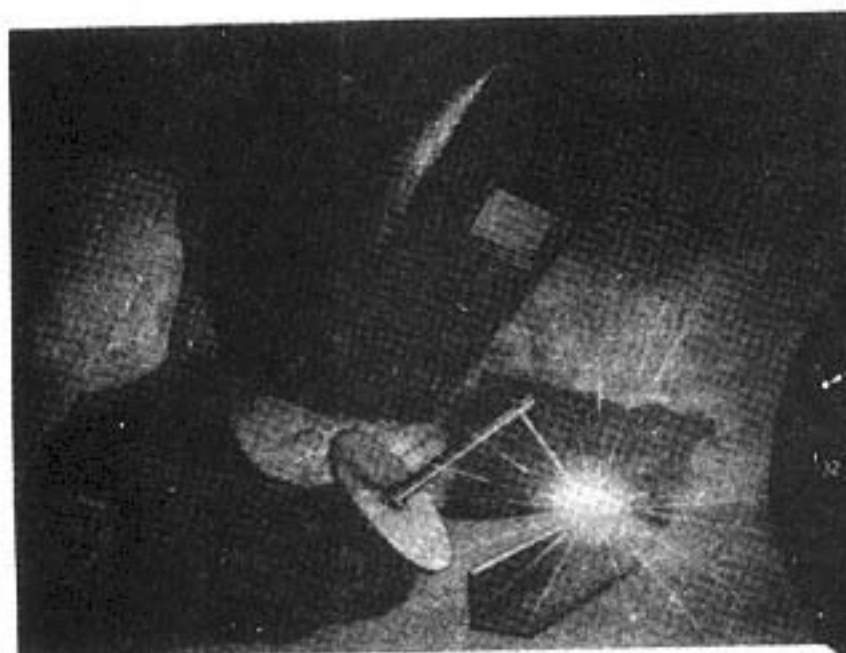
If you want the tool very hard, quench in a saturated solution of salt water; for extreme hardness, quench in soldering acid. □



The pyrometer element as it is placed in the furnace, and, at right, a diagram showing the method of construction. The alloy wires, which are the sensitive part of the instrument, are bought ready for use



Welding Rod Holder and Mask



A good mask is essential. It protects the welder's eyes from ultraviolet rays and his face from particles of molten metal

Pop. Sci. Monthly 1937

By
KENDALL FORD

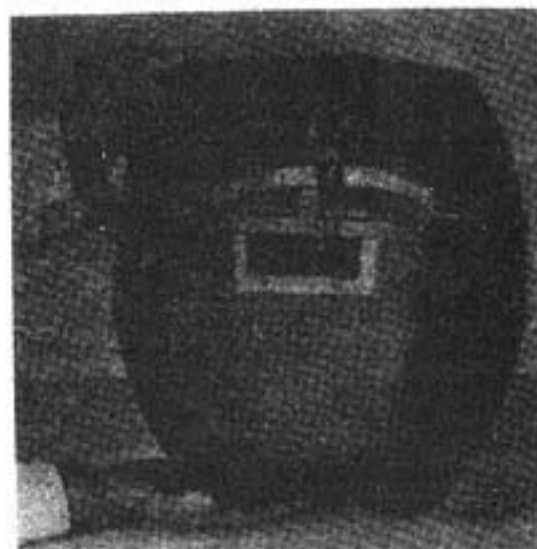
BEFORE the homemade arc welder described in the two preceding articles* of this series* can be put into operation, it is necessary to make a holder for welding rods and a mask.

Holder. Obtain round brass rod, $\frac{1}{2}$ by 15 in. Cut a piece 1 in. long for the end piece (Fig. 10) and drill as shown to hold welding rods up to $\frac{1}{4}$ in. in diameter. If it is desired to use larger carbon rods, provide an additional end piece.

Cut down one end of the remaining brass rod to a diameter of $\frac{1}{4}$ in. for a distance of 1 in. and thread as indicated. The threaded portion should be tapered at the end so that it will screw into the end piece and reach the farther side of the $\frac{1}{4}$ -in. hole. File the opposite end of the long rod flat, and drill and tap for a machine screw to hold the lug of the cable.

Provide a wooden handle with a $\frac{1}{2}$ -in. hole through the center, and add a fiber or asbestos-board guard. A piece of regular welding cable should be obtained to connect the rod holder with the transformer as it is more flexible.

Connecting Lug for Work. Drill and shape the lug from round copper rod $\frac{1}{2}$ by 3 in. as in Fig. 11. The side to be clamped next to the part being welded should be filed perfectly flat to insure a good contact. Solder rubber-

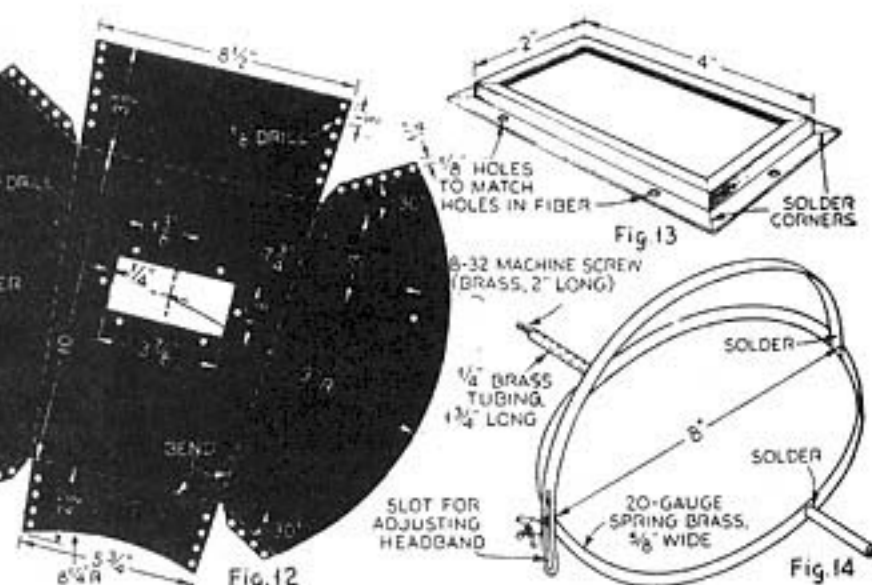


Rear view of the mask, showing glass frame and headband. The drawings are given above

covered flexible wire not smaller than No. 4 in the lug to connect with the transformer.

Mask. The operator's eyes and face must be protected. This point cannot be too strongly emphasized. The ordinary colored glasses such as are used for oxy-acetylene welding are worthless in preventing the harmful ultraviolet arc-welding rays from injuring the eyes. The mask also protects the face from the molten particles of metal that are continually flying from the arc.

Obtain $\frac{1}{32}$ -in. thick fiber, 16 by 18 in., and cut and drill as in Fig. 12. Bend along the dotted lines, but not sharply or the fiber is apt to crack. Rivet or bolt at the corners. The special glass,



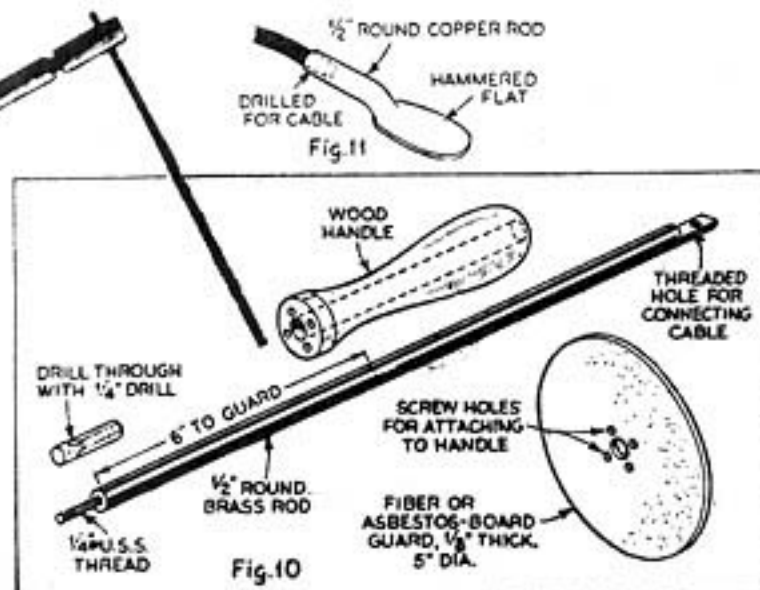
2 by 4 in., may be obtained from dealers in welding supplies. Place a piece of clear glass on each side of the colored glass. The outside piece will become pitted and will have to be replaced occasionally. A glass-holding frame may be made as in Fig. 13 from 20-gauge metal. Fasten it to the fiber with small machine screws.

Approximately $3\frac{1}{2}$ ft. of 20-gauge spring brass $\frac{5}{8}$ in. wide will be required for the headband (Fig. 14). The mask is slipped on the extended machine screws on the headband and held with knurled or wing nuts. This arrangement enables the mask to be swung upward for inspecting work. Before the headband is fastened to the mask, wrap it with several layers of cotton tape to pad any sharp edges.

Operating the Welder. In order to give a preliminary tryout, connect the reactance coil in series with the transformer to the supply line. Since the reactance coil limits the amount of current flowing through the transformer, it is advisable to have all of the reactance winding in the circuit until the user becomes familiar with the procedure. Later the leads may be connected to the reactance-coil terminal that will allow the proper amount of current for a given job to flow. For the sake of uniformity, the No. 1 terminal on the reactance coil should be left connected to



Homemade rod holder for arc welding and, at right, details of the parts. In actual use, the hand must, of course, be protected by a heavy gauntlet of leather



the transformer, and the necessary variations made on the remaining terminals.

WEAR leather gauntlets as a protection against burns. Clamp the copper lug to a scrap piece of steel, place a pointed carbon rod in the holder, and practice striking an arc. If a regular carbon welding rod is not available, a "B" battery carbon will be a satisfactory substitute. It is easier to hold an arc with a carbon rod than it is when using a regular arc-welding metal rod, so the carbon is better to start with.

Welding rods are available in assorted types and sizes, each adapted for a particular kind of welding. It is advisable to have a supply of each on hand in sizes ranging from 1/16 to 3/16 in.

The transformer is so designed that it draws a negligible amount of current from the line when the arc is not being used. Each particular job will require a certain amount of current and a certain size rod to do the work satisfactorily. As the size of the job increases, that is, the depth and the width of the weld, more current will be drawn from the secondary, with a proportional increase in the current flowing through the primary. That fact should be kept in mind when connecting the welder to the supply line.

Where the supply line is No. 14, the current should be regulated by means of the reactance coil so that the transformer does not draw current in excess of which the line is fused. Where the

supply line is No. 8 or larger, the transformer may be connected directly to the line for the larger jobs, without the use of the reactance coil. When an alternating current of 220 volts is available, the transformer will draw just half the current it would draw when connected to 110 volts, with the same output from the secondary. This permits a smaller size line to be used for supplying the current.

Carbon rods may be used for cutting and welding metals other than steel. Since carbon rods cause the steel to become rather brittle, it is advisable to use steel rods when welding steel.

Spot Weld

How to construct a Portable Spot Welder at Low Cost

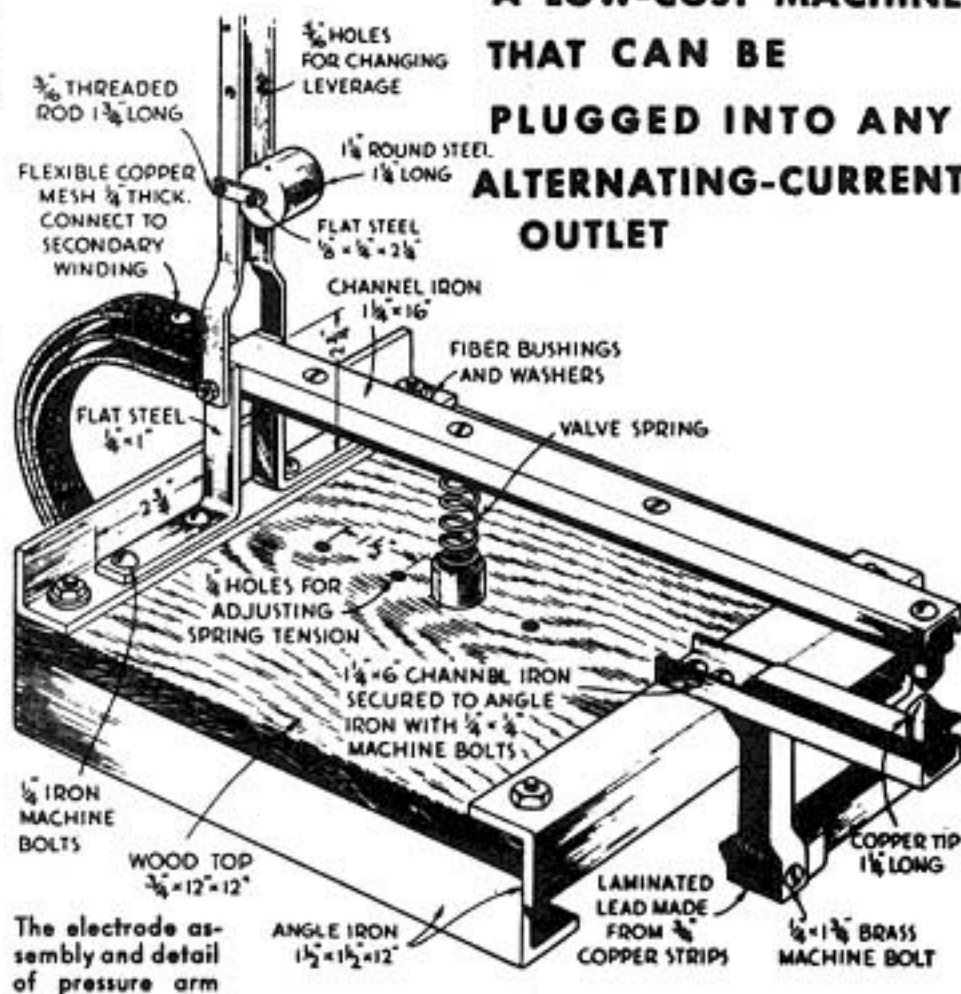
HERE is a small spot welder you can build at a cost that is but a fraction of the price of commercial spot welders of similar capacity. The writer obtained the necessary materials for about fourteen dollars. The unit is compact and portable, and its adjustable leverage and spring-tension features make it adaptable to an extremely large variety of welding jobs.

While in no sense a substitute for arc welding*, this spot-welding equipment is a valuable

adjunct to any home workshop. It is particularly useful in joining together metals that are too light for any other form of welding, but its application lies not in that field alone. Scores of points on the modern automobile are spot-welded together where they were formerly held with screws and bolts.

Spot welders operate on a somewhat different principle from arc welders. In arc welding, the heat generated by the arc causes

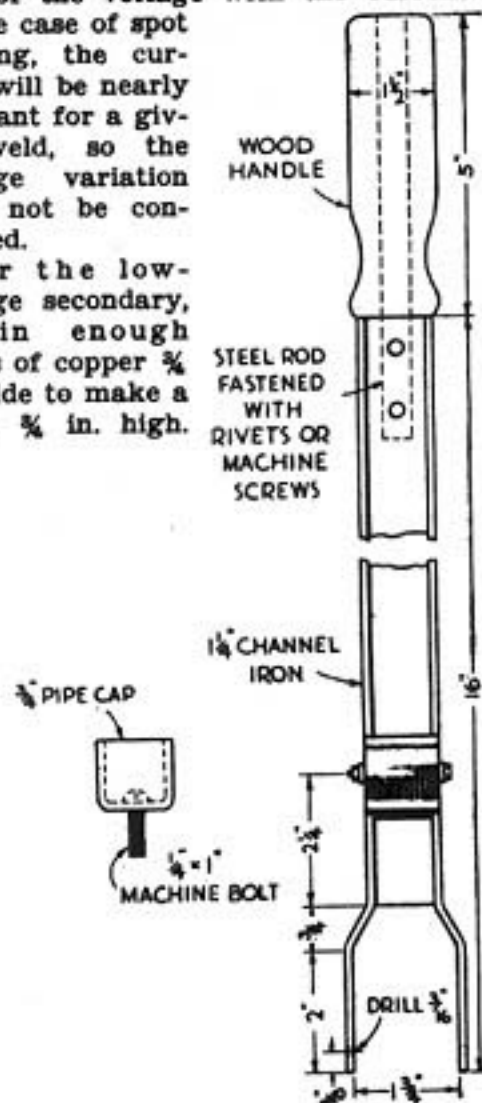
A LOW-COST MACHINE THAT CAN BE PLUGGED INTO ANY ALTERNATING-CURRENT OUTLET



the metal to melt and fuse together. In spot welding, a relatively high resistance joint between two good conducting points is brought to a white heat by the passage of current, then welded together by pressure. As in the case of arc welding, a transformer is used, but the voltage across the secondary is reduced to a few volts, with the current raised in indirect proportion to several hundred amperes.

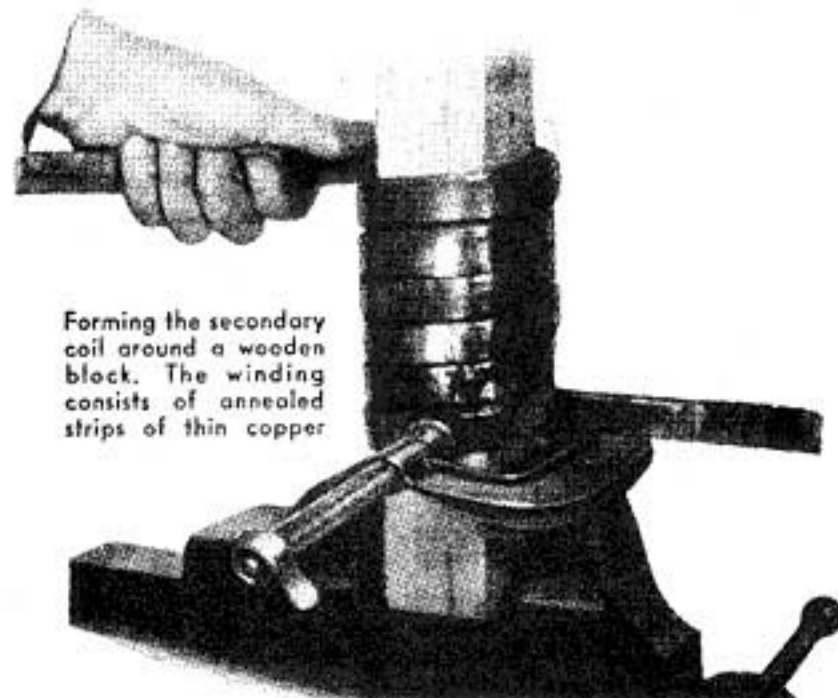
The core, clamps, primary coils, and baseboard are identical with those required for the arc welding transformer. Assemble the core, as outlined for the arc welder (see P.S.M., June '37, p. 69). Wind the two primary coils as directed, but place the two coils on the same leg of the core, with the windings running the same direction. The coils on the welding transformer were placed on opposite legs to cause a uniform variation of the voltage with the current. In the case of spot welding, the current will be nearly constant for a given weld, so the voltage variation need not be considered.

For the low-voltage secondary, obtain enough strips of copper $\frac{3}{4}$ in. wide to make a stack $\frac{3}{4}$ in. high.

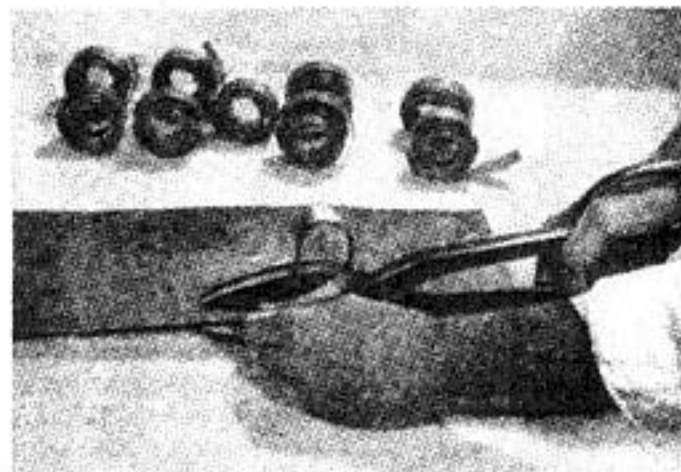


The strips should be 8 ft. long and may be No. 20 gauge or smaller annealed copper. The gauge is of no importance provided there are a sufficient number of pieces to make the size of laminated conductor required. If copper strips are not obtainable, they may be cut from a larger sheet of copper.

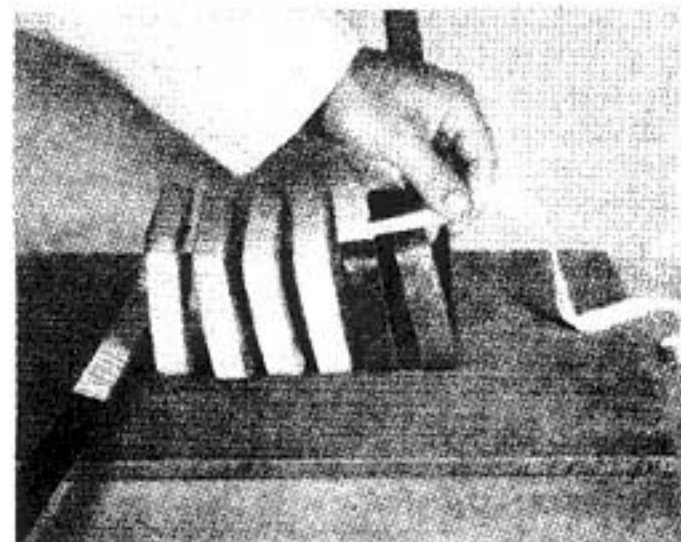
Provide a wood form, $2\frac{3}{4}$ in. square and 8 in. long, to serve as a winding form for the secondary. Bind the strips together with strips of friction tape at several points along their length—



Forming the secondary coil around a wooden block. The winding consists of annealed strips of thin copper



The strips may be cut from a large sheet of copper if necessary. Each is $\frac{3}{4}$ in. wide and 8 ft. in length



The secondary coils are covered with cotton tape, the turns being half-lapped so there are two thicknesses

tightly enough to hold them in place, but not so tight as to prevent a movement of the outside strips as they are wound around the form. Clamp one end of the strips to the wood form, place the form in a vise, end upward, and wind six complete turns around the form. As each turn is wound, the



Left, cleaning the points of the copper electrodes with an ignition file. They wear away in use and must be kept in shape.

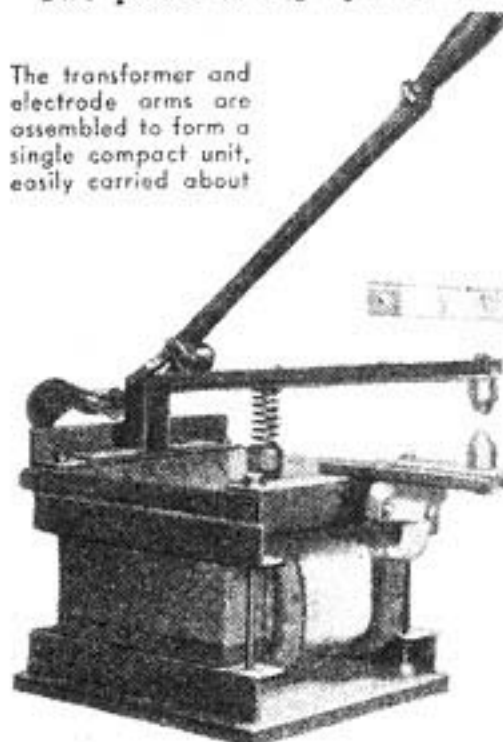
sides and corners should be hammered to shape with a wood mallet.

Remove the coil from the form and hook each end over a nail driven into a board, so that the turns will be separated for taping. Compute the length of the necessary leads at each end of the coil and cut the remaining strips off with tin snips. Begin taping the leads near the end with cotton tape and follow through the coil to the opposite end. The tape should be half-lapped so that there will be two thicknesses of tape on the coil. Tape the turns together, lengthwise through the coil, and cover with shellac or insulating varnish.

Drill $\frac{1}{4}$ -in. holes in the ends of the coil leads so that they may be extended as shown in the drawing. Place the secondary coil over the core leg, with the leads at the top. Insert the remaining core laminations, clamp the core together, and place on a wood base. Provide a $\frac{3}{4}$ -in. top as illustrated.

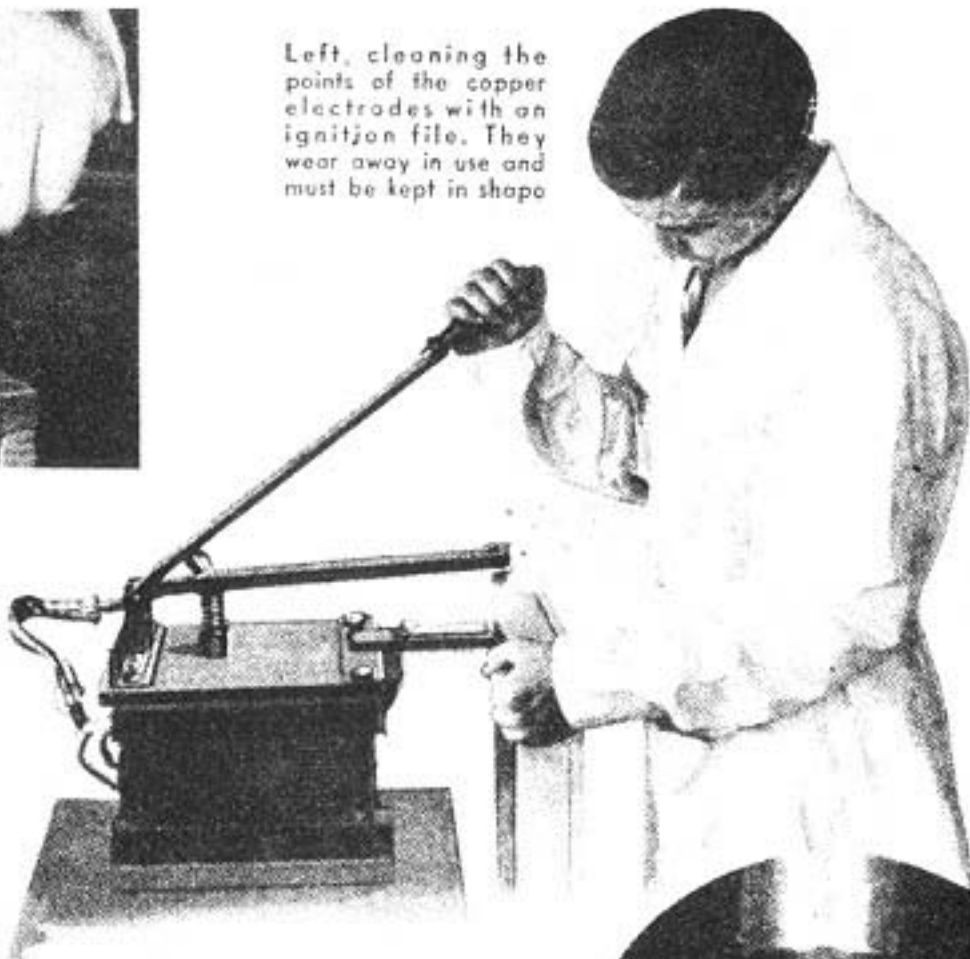
Two pieces of $1\frac{1}{2}$ by $1\frac{1}{2}$ -in. angle

The transformer and electrode arms are assembled to form a single compact unit, easily carried about.

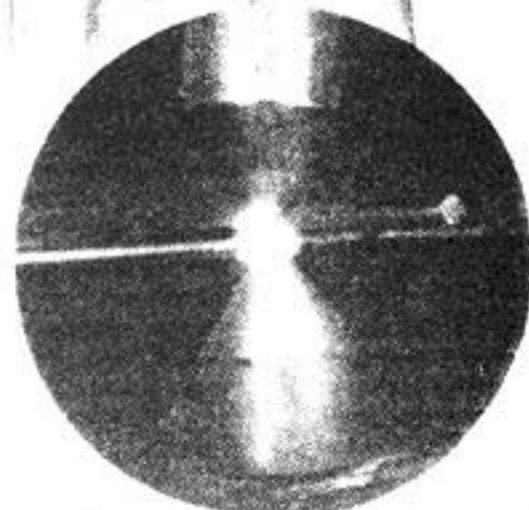


iron, 12 in. long, will be required for the electrode brackets. It will be necessary to insulate the rear bracket from the tie rods with pieces of fiber tubing and fiber washers.

Obtain a piece of $1\frac{1}{4}$ -in. channel iron, 6 in. long, for the bottom electrode hold-



The spot welder is particularly useful in joining metals that are too light for any other form of welding. Right, metal between the tips turns white hot instantly.



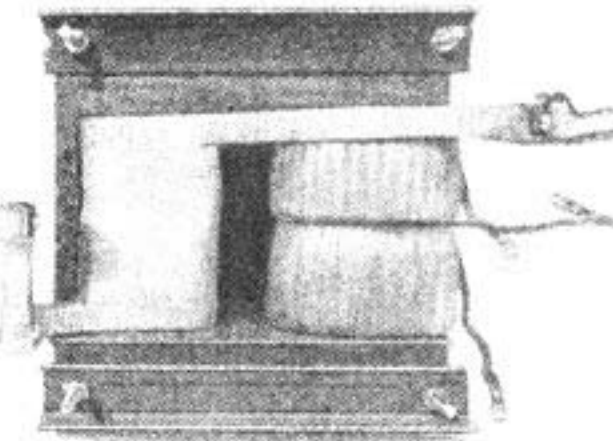
end of the channel with the pieces of copper strip that were cut off the secondary coil, and drill a $\frac{9}{32}$ -in. hole in the end of the lead to line up with the $\frac{1}{4}$ -in. hole in the channel iron.

Take two pieces of flat steel, $\frac{1}{4}$ by 1 by $5\frac{1}{2}$ in., bend at right angles, drill where indicated, and bolt to the rear angle iron. Obtain a piece of $1\frac{1}{4}$ -in. channel iron to serve as the upper electrode arm, and drill where indicated.

To allow for variations in construction and assembly, it is advisable to forego drilling the hole in the end of the arm for the copper tip until after a trial assembly.

The copper tips should meet perfectly, because a variation in either the upper or lower arm would throw them completely out of line.

A $\frac{3}{4}$ -in. laminated lead, secured to the channel iron by means of flathead brass machine screws, extends several inches beyond the end of the iron, where it is connected to the remaining secondary lead with flexible braided copper, $\frac{1}{4}$ in. thick, such as is used for connecting brushes on large generators. This can



A view of the transformer to show particularly how the leads are brought out from the secondary. The connections are indicated in the diagram above.

er, and drill two $\frac{1}{4}$ -in. holes in one end to bolt it to the front angle iron, and one $\frac{1}{4}$ -in. hole in the opposite end to hold the bottom electrode in place. Cut a $\frac{3}{4}$ -in. hole through the flat part of the channel iron, through which the transformer lead may pass. Bolt the 6-in. piece of channel iron to the angle iron with $\frac{1}{4}$ -in. iron machine bolts, $\frac{1}{4}$ in. long. Extend the secondary lead to the

usually be obtained from motor repair shops, but if it is not available, the top lead may be continued in a large loop to the secondary coil.

THE upper electrode arm is secured to the flat steel angles by means of a 3/16-in. threaded rod, which also serves to hold the pressure arm in place. The pressure arm consists of an additional piece of 1 1/4-in. channel iron, 16 in. long, drilled and shaped as shown in the detail drawing. The flat portion of the channel iron is removed for a distance of 2 1/2 in., after which the end is shaped and drilled as shown. A piece of 1 1/4-in. round steel is attached to the pressure arm where indicated. Additional holes may be drilled in the sides of the arm so that the position of the round steel piece may be moved to change the leverage. Drill a wood handle to slip over a 1/2-in. round iron rod, which is secured to the arm with rivets or machine screws.

An automobile valve spring with a 3/4-in. pipe cap to hold it in place provides the tension for the upper electrode arm.

A 3/4-in. machine bolt, 1 in. long, should be threaded into the bottom of the pipe cap and inserted into a hole in the wood top. Several holes should be drilled in the top so that the spring may be moved to change the tension. Valve springs

from small cars fit the pipe cap very snugly, and with the springs from larger cars it may be necessary to remove the threads from the pipe cap.

The copper tips are secured to the upper and lower arms by means of 1/4-in. brass machine bolts. If only the current carrying capacity were considered, the copper tips would not need to be any larger than the laminated copper lead. However, considerable heat is generated at the point of contact so it is advisable to make the copper tips larger to assist in dissipating the heat. The tips should be tapered to a 1/8-in. point, and since they wear away when in use, they should be removed from time to time and retapered. The ends of the tips should be kept clean and flat, which may be accomplished by filing between the points with an ignition file.

Since the amount of current required will vary with the thickness of the pieces of metal being welded together, some means of regulating the current through the primary of the transformer will be necessary. The reactance coil described with the arc welder, (P.S.M., July '37, p. 87) will allow the current to be varied over a wide range and it may be used with the spot welder without any changes. Like the arc welder, the spot welder may be used on either 110 or 220

volts, alternating current. The wiring diagram shows how the coil terminals are brought out to the terminal strip so that they may be used in parallel for 110 volts, or in series for 220 volts.

When using the spot welder, the two pieces of metal that are to be welded are placed on the point of the lower copper electrode, and the upper electrode is brought down against the upper piece of metal. Since the conducting path between the metals being welded offers a high resistance to the current flowing from one copper tip to the other, the area around the copper tips will quickly come to a white heat. Further pressure will make the metals fuse together, after which releasing the pressure on the arm will cause the copper electrodes to spring apart.

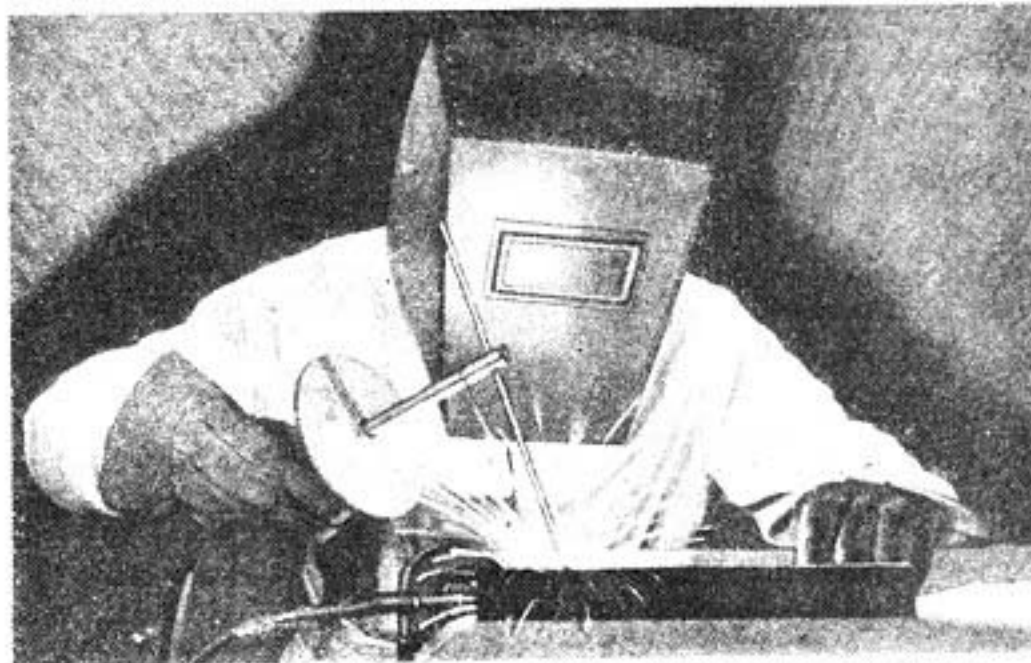
TO MAKE a satisfactory spot weld, the metals should be clean and free from scale, and be of material that has a higher resistance than copper, such as iron or steel. Copper could not be welded satisfactorily because there would be a tendency for the copper to fuse with the electrodes. The operator should experiment with various kinds and thicknesses of metals until he becomes familiar with the amount of current and the pressure required for any kind of weld.

EFFICIENT Arc Welder Built Cheap

From Popular Science 1937

In this age of steel, welding takes its place with gluing as one of the most common and universally useful operations. If you work with metal, you should have welding facilities. Fortunately, you can make most of the equipment you need.

By Kendall Ford



Welding with an entirely homemade outfit that can be plugged into any ordinary alternating-current circuit. The mask and rod holder will be described later.

HERE is an inexpensive homemade arc welder that can be plugged into any ordinary alternating-current circuit as easily as an electric iron. Its adaptability to a wide range of jobs makes it equally suitable for the home workshop or a commercial repair shop, and it will perform as satisfactorily as commercial welders costing several times as much.

Allowing for variations in the price of the materials in different sections of the country, the cost should not exceed fifteen dollars. If salvaged materials such as bolts, angle iron, and screws are available, making it necessary to purchase only the wire and the transformer laminations, the cost may be reduced about a dollar and a half.

For alternating-current arc welding, either a straight transformer or an autotransformer is used. Although somewhat cheaper to build, the autotransformer may give the operator a disagreeable, if not dangerous, shock unless he takes the pre-

caution of connecting it to the line in a certain way. This is particularly true when the supply-line voltage is 220 volts. The transformer to be described is of the straight transformer type, that is, one having a separate primary and secondary winding, which eliminates any possibility that the operator will receive a shock.

Briefly, the principle of arc welding is based upon the fact that when the electrode is brought into contact with the article to be welded and then drawn a short distance away, the arc

formed between the point of contact and the electrode will cause the temperature of the immediate area to rise to about 6,500 degrees F. This tremendous heat causes a pool of molten metal to form, which, when cooled, joins the parts in a firm, sound union.

Two types of electrodes may be used in arc welding, each of which has its own applications. The metal type supplies the metal for the weld, whereas the carbon type merely forms the arc to which welding rods must be fed.

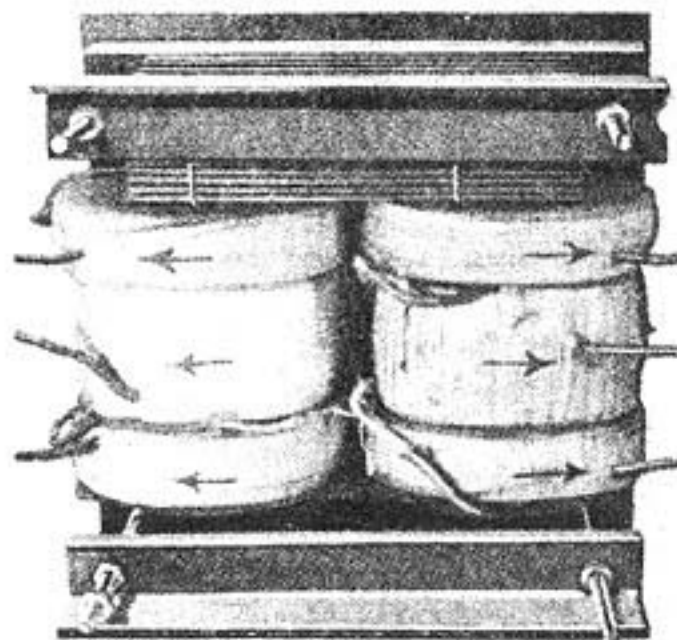
The transformer to be described has a normal rating of 2,500 watts and an overload rating of approximately 4,000 watts for short periods of time. Approximately 50 lb. of No. 26 gauge transformer iron will be required for the core. This may usually be obtained from the salvage yard of the local power company. If transformer iron is not available, stovepipe iron, available at tin shops, may be substituted. Approximately 45 sq. ft. will be required.

Since the size of the sheets of iron available in either case will not cut up evenly, allowance for waste will have to be added to the amounts mentioned. In case stovepipe iron is used, it is advisable to coat each separate piece with thin shellac and allow it to dry before using.

Cut the iron to the sizes shown in Fig. 1, and provide enough of each size to make two stacks, each 5 in. high when pressed closely together. Divide the longer core pieces, or laminations, into two equal stacks, and form into core sections as shown in Fig. 2. A temporary form may be made by driving nails into a board. The end nails should be the length plus the width of a lamination apart, or 11 in. When half of the longer laminations have been alternately stacked, press them together and wrap the strips of friction tape around the section.

Remove the laminations from the form about 1 in. of the solid portion of the section extending beyond the jaws of the vise. Tape the solid portion of the core by moving the whole section outward from the vise about 1 in. at a time. Take the taped section from the vise and wrap it with an additional layer of friction tape. Repeat the operations with the remaining long laminations, and coat each section with shellac. Before the shellac dries, cover the

How the winding form is used in preparing one of the primary coils



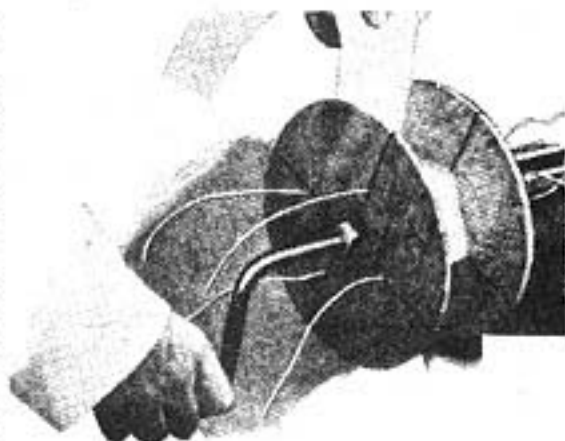
The transformer has a normal rating of 2,500 watts

taped portion of each section with a layer of regular insulating cloth or tape.

The windings consist of two primary coils and four secondary coils, all wound with No. 10 D.C.C. (double cotton-covered) wire, of which approximately 36 lb. will be required. It will be noted in Fig. 4 that each group of windings is connected in parallel, which permits using wire of a size that can be easily wound and makes possible a more efficient arrangement of the coils on the core. If single coils were used, the primary winding would have to be No. 7, and the secondary No. 4, both of which would be extremely difficult to wind. With the primary divided into two sections, the transformer may be used either on 110 volts or 220 volts simply by changing a connection at the terminal strip.

A winding form for winding the primary and secondary coils is shown in Fig. 3. Since the primary coils are just twice as wide as the secondary coils, the wood center of the winding form is in two sections so that one of them may be used when winding the secondary coils.

Place a piece of small size wire or strong string in each slot in the center of the winding form to serve as bindings for the completed winding. Wrap the center section of the form with several layers of



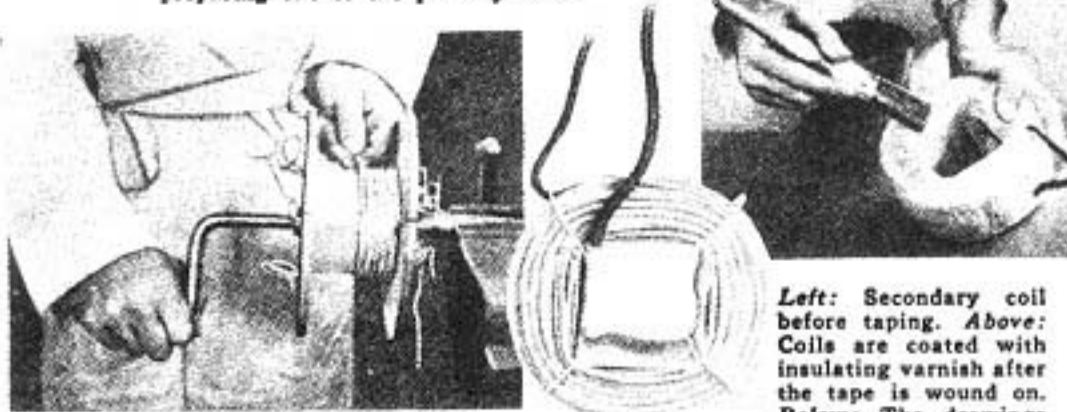
thin cardboard and insert about 10 in. of the No. 10 wire through the hole provided in the side of the winding form to serve as a coil lead. Place a short piece of pipe in a vise, insert the shaft of the winding form into the pipe, and proceed with the winding of the coil.

The turns should be placed on evenly with enough strain to make the wire follow the square outline of the winding form. If the winding is put on loosely, it will tend to assume a circular shape and



Core laminations are pressed firmly together in a vise and taped an inch

at a time. Below: Wrapping the coil form with cardboard strip before winding



Left: Secondary coil before taping. Above: Coils are coated with insulating varnish after the tape is wound on. Below: The drawings

take up more space than it should. The coils may be wound either to the right or to the left, but in either case they should all be wound in the same direction. Two coils of 210 turns each will be required for the primary, and four coils of 140 turns each for the secondary windings.

As each winding is completed, bring the ends of the tie wires or strings together over the coil, take the winding form apart, and remove the coil from the form. Tape the coils, in and out through the center, with cotton or linen tape. Leave the cardboard in the center of the coil in place, but remove the tie wires as the taping proceeds around the coil.

Since the insulation on the ends of the coils is apt to become frayed during the assembling of the transformer, it is advisable to place short pieces of cotton sleeving, such as armature winders use, over the leads of each coil. Give each taped coil a coating of insulating varnish or shellac, and allow it to dry.

Set the completed core sections on end and insert one half of the total number of short core laminations in such a way as to join the two sections together. These laminations are placed alternately, similar to the longer ones, as indicated in Fig. 2.

The coils are placed as shown in Fig. 5 so that those on one leg of the core will have their windings running in an opposite direction to those on the other leg of the core. It is advisable to mark the coils with an arrow to indicate the direction of the end lead of each to facilitate connecting the coils to their terminal strips. When the coils are in position, the remaining core laminations may be placed between the core sections.

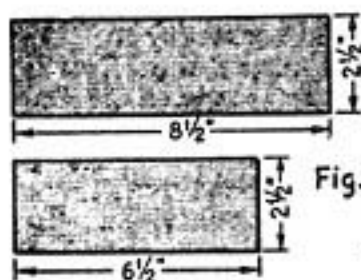


Fig. 1

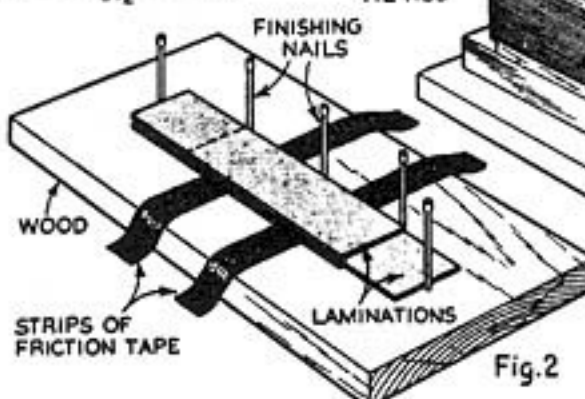


Fig. 2

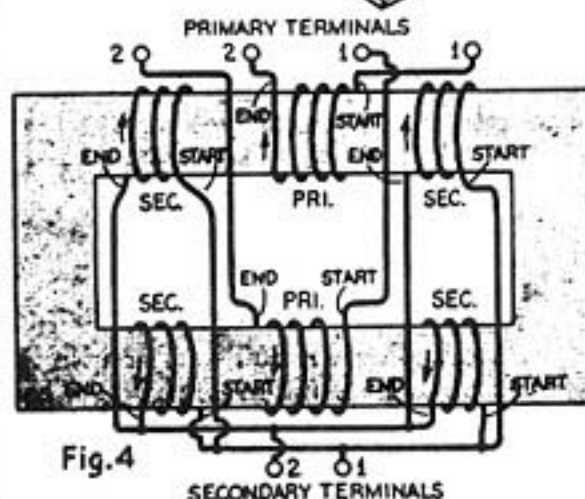


Fig. 4

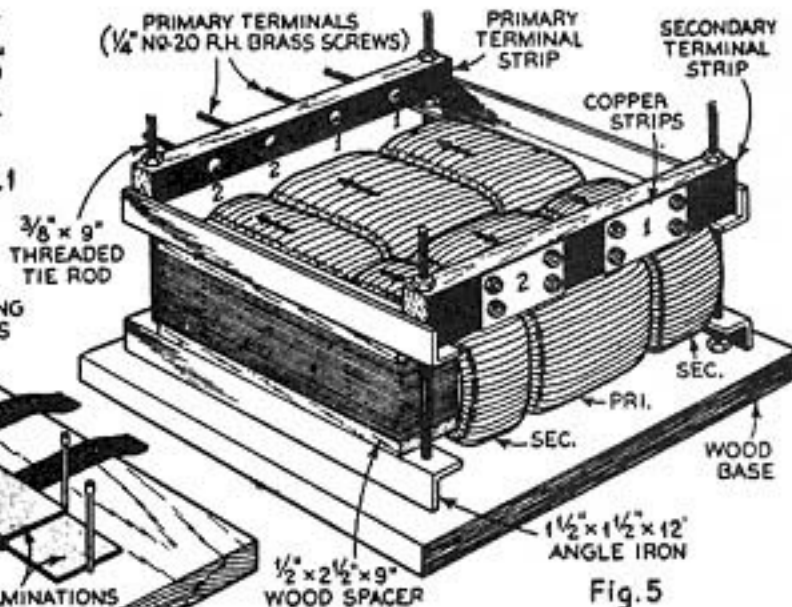


Fig. 5

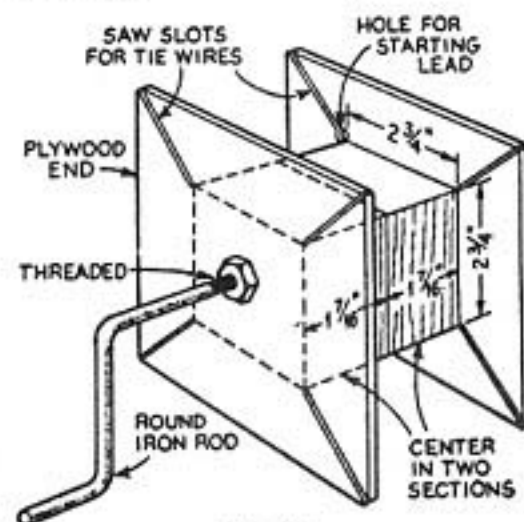


Fig. 3

NEW PLUG-IN

Arc-Welding Outfit

POPULAR SCIENCE 1937

How to mount the transformer and make a reactance coil for regulating the output

ONCE the transformer for your plug-in arc-welding outfit has been wound as described on page 283, the remainder of the work is comparatively simple. It is necessary to mount the transformer, make the connections, and provide a reactance coil for regulating

the output. Four pieces of 1 1/2-in. angle iron, 12 in. long, and four 3/8-in. tie rods are required to clamp the core of the transformer. The length of the rods will depend upon the thickness of the top board of the transformer, but should not exceed 9 in. A

The welding transformer. All the six coils are in place, and the remaining core laminations are being inserted



wood or fiber top, which may be from 1/4 to 1 in. thick, should be used to protect the terminals from short circuits.

Provide wood spacers between the angle irons and clamp together over the core ends, as shown in the drawing marked Fig. 5 in last month's article. Make terminal

strips to fit over the tie bolts, with terminal screws as indicated in the same drawing and illustrated in three photographs on this page. Four $\frac{1}{4}$ -in. brass machine screws will be required for the primary terminals, and eight for the secondary terminals.

The secondary terminals are in two groups, with the four terminals of each group bridged together with strips of No. 20 gauge copper, $\frac{3}{4}$ in. wide. The leads from the secondary coils should be arranged in two groups, the starting leads in one group and the end leads in the other. Connect the starting leads to the terminal screws marked 1 on the diagram of connections (Fig. 4, last month), and the end leads to the terminal screws marked 2.

The primary coils are connected exactly as shown in Fig. 4 because that arrangement enables the coils to be connected in parallel for 110 volts or in series for 220 volts. It is essential that the coils be placed on the core so that their windings are in the proper direction and that they be connected as indicated, otherwise the currents flowing in the coils will not be in opposition and the transformer will not function.

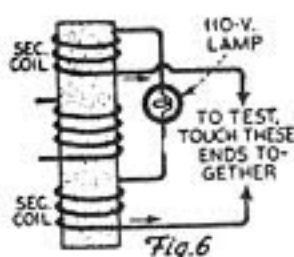
If the builder is in doubt as to the correctness of his connections, he may make the simple test shown in Fig. 6. With the secondary coils connected in parallel, no current will flow between similar ends of the coils due to the fact that the current flows to or from the terminals of all coils at the same instant. Where the connections of a coil are reversed, current will flow from one coil into another because the current set up in one coil is in the opposite direction, with respect to the terminals, to the current set up in the other coil.

To test the coil connections, leave the ends of the secondary coils free and connect one primary to a 110-volt line. Connect a lamp to the starting leads of two coils, and touch the remaining two leads together. If the lamp fails to light, the leads are correct and may be connected to the proper terminals. If the lamp lights, it indicates that a starting and an end lead have been reversed.

On an incorrect connection the combined voltage of two coils, or 140 volts, will flow through the lamp, therefore it will light to more than normal brilliancy. However, if it is lighted for just a short time, the lamp will not be damaged. Test the remaining coils in the same manner.

Where it is found necessary to splice the wire, either within the coils or at the terminals, it may be done by removing the insulation from each wire for about 1 in. and binding the two ends together with a layer of fine wire, after which the splice should be soldered and taped.

IT WILL be noted that the design of the transformer departs from the conventional method of placing the primary coils on one leg of the core and the secondary coils on the



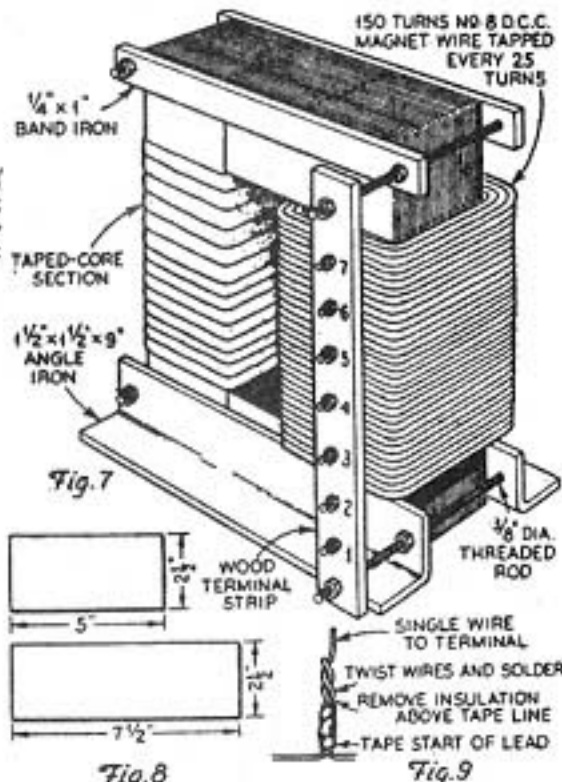
The reactance coil and a method of testing the transformer windings are shown at left

other. The method illustrated follows commercial practice and provides satisfactory voltage regulation, which is quite essential in an arc-welding transformer.

As specified in the previous article, the transformer has a normal rating of 2,500 watts and an overload rating of approximately 4,000 watts. Due to the fact that the current required for various welding jobs will vary over a wide range, some means must be provided to regulate the output of the transformer. Of several methods available, such as a movable core section or taps on the primary coils, a separate reactance coil seemed the most practicable. This method eliminates complicated coil connections and gives a more compact transformer unit.

The reactance coil is shown in Fig. 7 and the photograph immediately below it. The same method of assembling the core is used as with the transformer. The sizes of the core laminations are given in Fig. 8. Approximately 38 lb. of transformer iron will be required.

Since taps are to be taken from the winding, it will be easier to wind the wire directly on the core rather than on a form. The core section should be well insulated before winding to avoid any possibility of the wire's coming in contact with the core. Wind 25 turns of No. 8 D.C.C. (double cotton-cov-

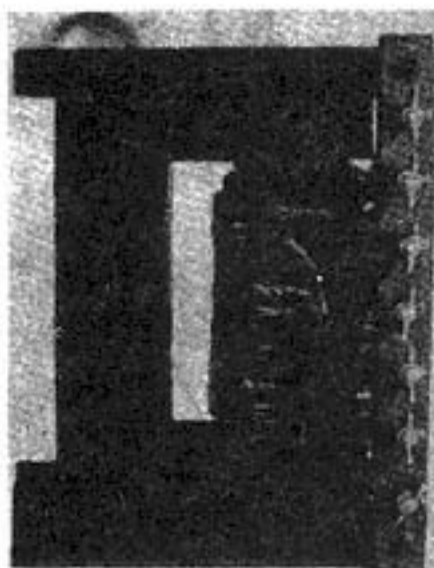


ered) wire on the core section and bring out a tap as shown in Fig. 9. Continue the winding, with a tap brought out every 25 turns, until 150 turns have been wound on the core.

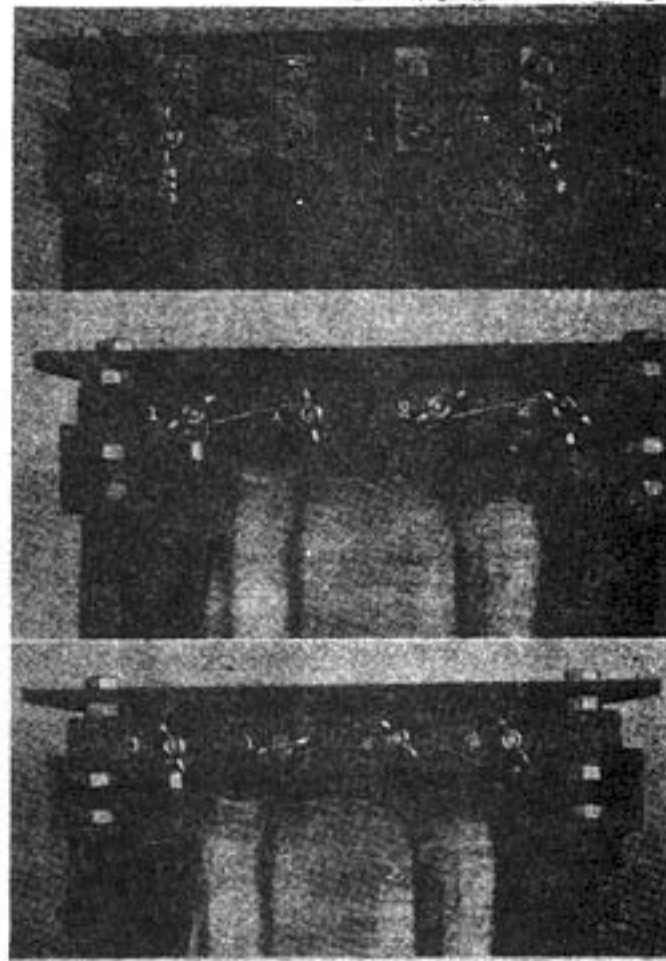
ASSEMBLE the core and clamp the ends together as shown in Fig. 7. Provide a terminal strip and connect the ends of the coil to terminals 1 and 7, with the intermediate taps connected to the terminals between.

Approximately 10 lb. of wire will be required.

Continued on Next Page



The complete reactance coil, which is tapped every twenty-five turns



At top: Secondary terminal strip of the transformer. Center: Primary terminal strip as connected for 110 volts. Bottom: For 220 volts. Left: Making a splice

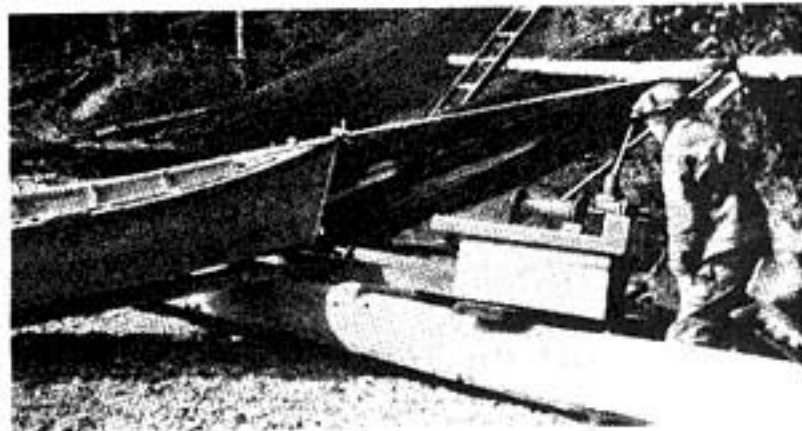
quired for the reactance coil. If it is desired to use No. 10 wire for the coil, the wire should be doubled, that is, two strands should be wound on at once. This makes the wind-

ing a little more difficult, but it permits one size of wire to be used on both the transformer and the reactance coil. If No. 10 wire is used, the length of the 5-in. lamina-

tion shown in Fig. 8 should be increased to 6 in. to provide additional winding space, with a corresponding increase in the length of the angle-iron and band-iron clamps.

AUTO TRANSMISSION SERVES AS WINCH

Popular Science Monthly,
October 1936



Showing how the mechanism can be used to haul a boat up a long beach onto a dock or platform

BY USING a junked auto transmission, a convenient and effective hand winch for hauling and hoisting can be made. The one illustrated was designed specifically for use in pulling a rowboat up a long beach onto a dock, but can be used also for lifting heavy loads and other similar work. It was made from a small transmission, but for heavier work, transmissions from larger cars could be selected.

The three shifts from high, second, and low adapt the winch to light, medium, and heavy loads. These changes can be made very quickly. When there is no load on the drum, the shift can be put in neutral, the ratchet released, and the rope reeled off without turning the gears.

The drum, shown in Fig. 4 of the sketch, was made from a piece of 1-in. pipe, threaded at both ends, with two 1-in. floor

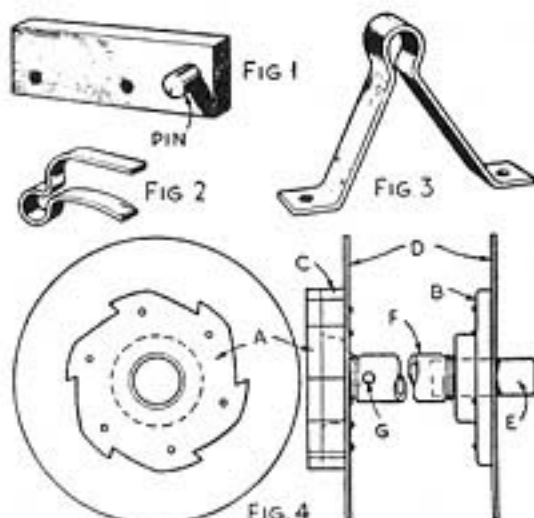
flanges. The length of pipe is determined by the amount of rope or cable to be used on it. In order to get the flanges to screw on the pipe for their full depth, it is necessary to cut the threads on the pipe smaller than standard or to tap out the flanges. In the mechanism shown, a 1-in. pipe was used as it just fitted over the end of the transmission driving shaft.

A in Fig. 4 is the flange next to the transmission, and C is a disk of hard wood riveted to A, both cut with notches for the ratchet. The two are riveted to a sheet-metal disk D, which in the present case was made of No. 18 gauge black metal, 6½ in. in diameter. Flange B at the outer end of the drum is riveted to a similar disk.

A short piece of 1-in. shaft E is driven into the drum spindle to form an outboard bearing supported by the bracket shown in Fig. 3. The drum is attached to the transmission

drive shaft by means of a 5/16-in. pin through hole G, which is drilled through the pipe after it has been forced onto the shaft.

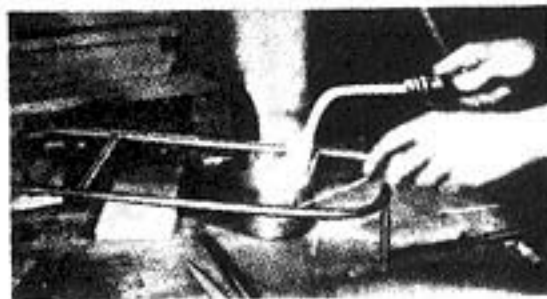
Figure 1 shows the metal block with a pin for the dog in Fig. 2. The holes in the block were drilled and spaced to fit stud bolts in the transmission casing. The block would have to be designed differently for some other transmission, but in any case should be attached rigidly to the casing in such a way as to allow the dog to engage the ratchet teeth. The removable crank was made from a starting crank by welding on a square socket that slips over the square end of the shaft entering the transmission. —GEORGE B. COUPER.



Only these few, simple parts are needed to adapt the transmission for use as a winch

HANDY ACETYLENE TORCH FOR HOME WORKSHOP

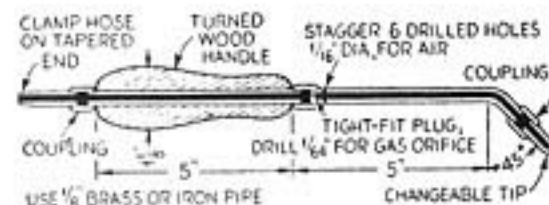
Popular Science
December 1936



My apparatus consists of the smallest size acetylene tank, 6 ft. of ¼-in. hose, and the torch. I picked up the tank in a junk yard for a dollar, and the hose cost only about nine cents a foot.

Refills for the tank cost about a dollar. A commercial torch costs several dollars, but

the one illustrated was made for a dollar. The torch's tip may be made smaller by first heating it, or the end may be plugged and then drilled to suit your needs. A coupling at each end of the handle keeps it in place. Six 1/16-in. holes are drilled in the ½-in. pipe to admit the air. —B. W. MORANT.



This acetylene torch is not a welding outfit, but follows the Bunsen-burner principle

ACETYLENE has many uses in the home workshop and is not costly if a simple torch, similar to the one illustrated, is constructed. The outfit will do brazing, soldering, annealing, sweating, and many other operations which require heat. It is not a welding outfit as pure oxygen is not used, the air being sucked in by using the principle of a Bunsen burner.

OLD MAGNETO PROVIDES PARTS FOR BUILDING

Small Workshop Compressor

By H. L. SWAN

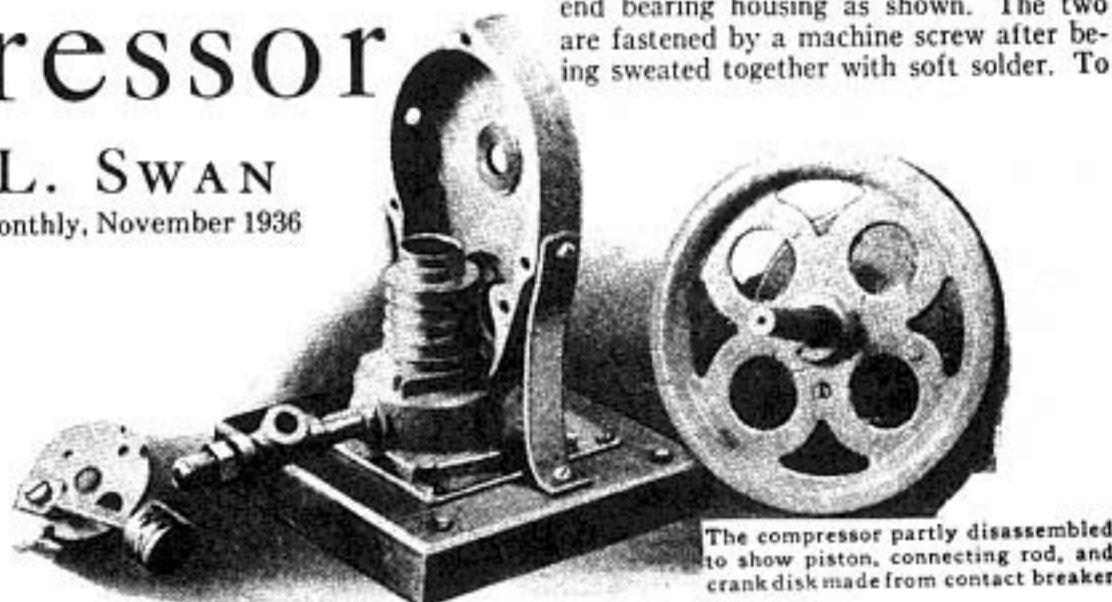
Popular Science Monthly, November 1936

MADE entirely out of scrap materials, the small compressor illustrated will raise a pressure of 25 lb. per sq. in. in a 6-cu. ft. tank in 25 minutes, which is ample for the average small gas torch. The consumption of line-shaft power is very small, an important consideration in many small shops.

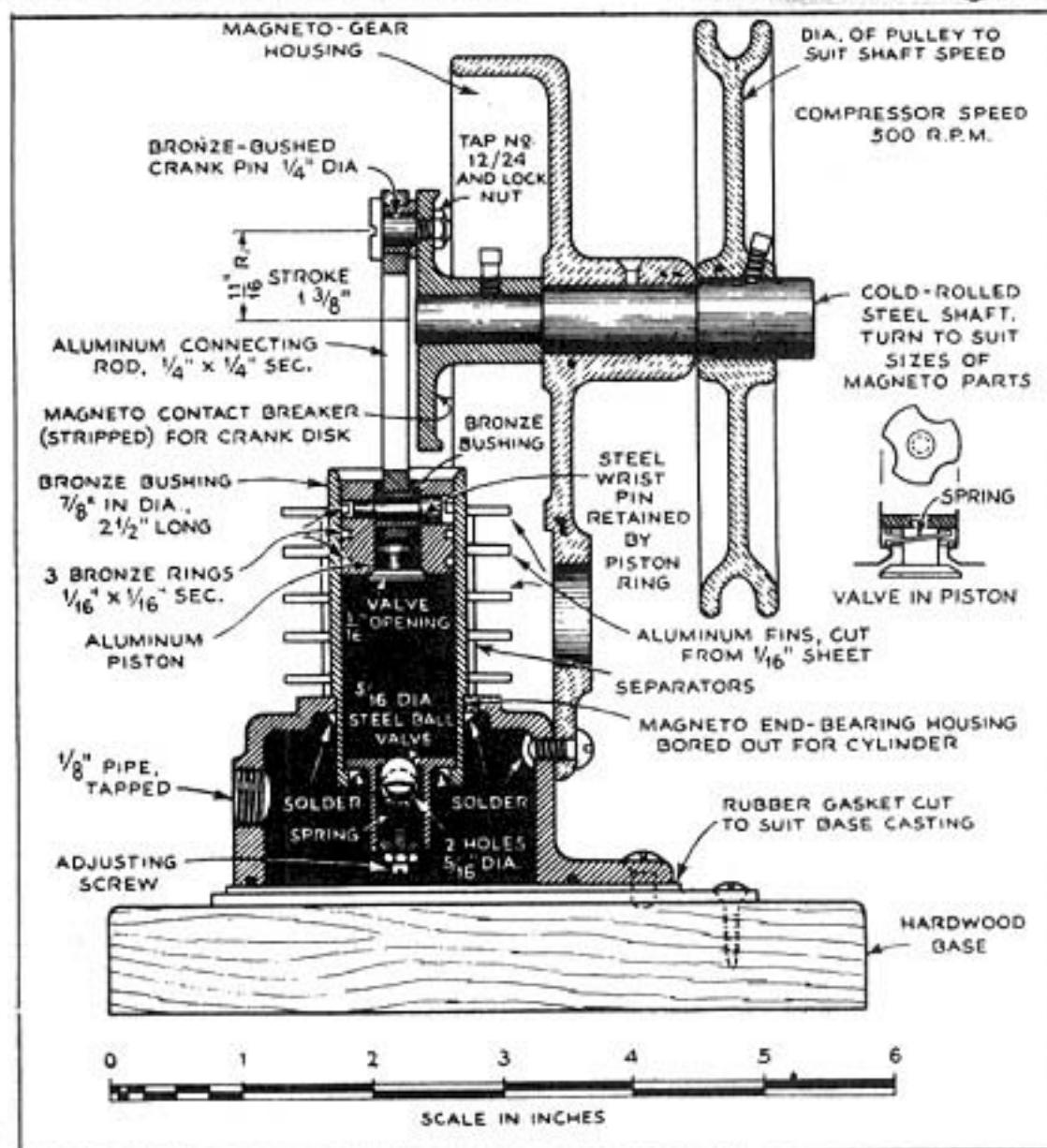
Construction of the compressor is clearly shown in the photograph and large drawing below. Simplicity is the keynote of its

construction throughout. The magneto which supplied most of the larger parts was purchased for fifty cents.

The method of procedure will be governed to some extent by the type of magneto available. Assuming the gear housing to be of cast iron and the end bearings to be of brass, it is a simple matter to saw and file out the gear housing to fit on the end bearing housing as shown. The two are fastened by a machine screw after being sweated together with soft solder. To



The compressor partly disassembled to show piston, connecting rod, and crank disk made from contact breaker



do this successfully, the cast iron must be thoroughly cleaned and well tinned. The axis of the shaft hole in the gear housing must be kept parallel with the finished face of the brass base. Do not fasten these parts together permanently at this stage.

Chuck the base in the lathe and bore for the cylinder. The size depends upon the bushing used for a cylinder, but the drawing indicates the proportionate allowances to be made for shoulders and the like.

The next step is to turn, bore, and lap the cylinder to an inside diameter of $\frac{7}{8}$ in., with other dimensions to suit the actual bushing available.

The cylinder bottom is soldered into place after fitting the simple ball valve. Make the valve seat very narrow, use a new ball, and tap the ball lightly on its seat before assembling to insure a tight valve.

Mount the cylinder in the base and solder as shown. Care must be taken to see that the bore is at right angles to the finished face of the base. Note the aluminum cooling fins, which can be turned in the form of washers and threaded on the cylinder before mounting, with aluminum separators between them.

The piston is built up from $\frac{1}{8}$ in. sheet aluminum cut into disks $\frac{7}{8}$ in. in diameter and riveted together. The rivets must be so placed that they will not interfere with the ring grooves or the piston-pin hole. The inlet valve in the base of the piston is retained with two turns of very light steel spring sprung into a groove just above the

valve seat. The ring grooves are turned $1/16$ in. wide and $1/16$ in. plus .002 in. deep. The rings are $3/8$ in. in diameter and $1/16$ in. thick, split at an angle of 45 deg. and sprung over the body into place, care being taken not to deform them.

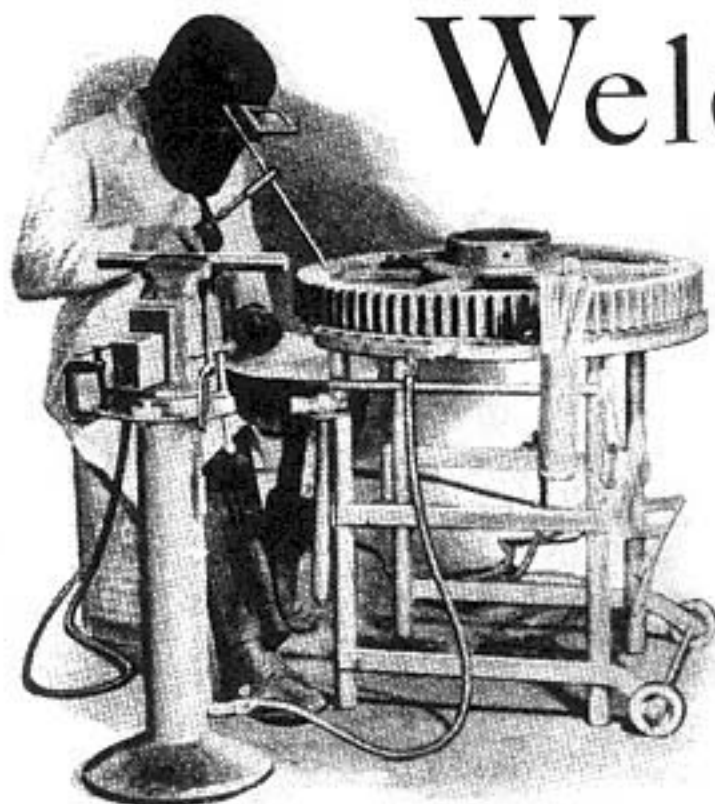
The connecting rod is also built up out of the $1/8$ -in. aluminum sheet, two pieces

being riveted together through the center section. The ends are left square in section as shown in the photograph and are fitted with bronze bushings for suitable pins, as indicated in the drawing.

Care is necessary to insure that all joints are air-tight, because with such a small displacement a very small leak will seriously cut down the efficiency of the compressor.

The best running speed is about 500 r.p.m.

The lightness of the oscillating parts and the comparatively heavy driving pulley, acting as a flywheel, reduce vibration to a minimum, but the braces shown are necessary to give general lateral stiffness. They are bent out of $5/8$ -in. flat steel $1/8$ in. thick, and fitted into place. □



Welder at work on gear resting on bench. Note vise stand

Welder's Bench

MADE FROM
SCRAP
MATERIALS

Popular Science Monthly,
September 1936

By
Leslie Kinning

M ECHANICS who have examined this welding table regard it as the most convenient and practical equipment of its kind they have found outside of expensive factory installations. It certainly has proved itself invaluable in daily service in the shop where it was built. From time to time various alterations have been made in it to improve the design, but the cost was low because most of the materials used in its construction were salvaged from the scrap and junk bins.

Many uses other than welding can be made of the bench. The large center opening makes it ideal for truing up warped disk wheels, as draw bolts can be inserted from underneath.

The top of the bench was made from a large discarded gear wheel. One side was cut straight with the torch, leaving 3-in. offsets at the ends. A $1/4$ -in. iron strap was welded around the remaining toothed perimeter, forming convenient hooking pockets for accessories and also preventing the clothes of the mechanic from being torn on the cogs.

The frame was built of $1\frac{1}{2}$ -in. pipe,

with strap-iron braces welded on. The lower rails extend beyond the rear legs, bending downward to form mounts for two iron wheels about 3 in. in diameter, which are held on the axle with washers and cotter pins. The $1/2$ -in. pipes just below the top house rods which, when pulled out, act as handles for raising the table on the wheels, after the manner of a wheelbarrow. It can then be moved with very little effort around the shop.

Pieces of tubing, welded to the legs, form sockets for hammer, wire brush, dusting brush, and chisel; and an angle on a lower rail is a handy projection for the ground clamp of an arc welder.

The accessories shown are also most useful. The can for electrodes was made of light tubing, the hook enabling it to be hung on the table edge at any convenient point. The little

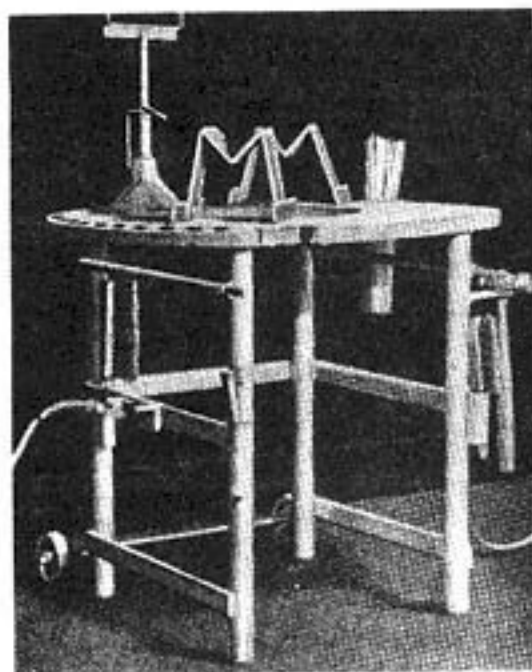


Portable vise with ground-clamp connection near base

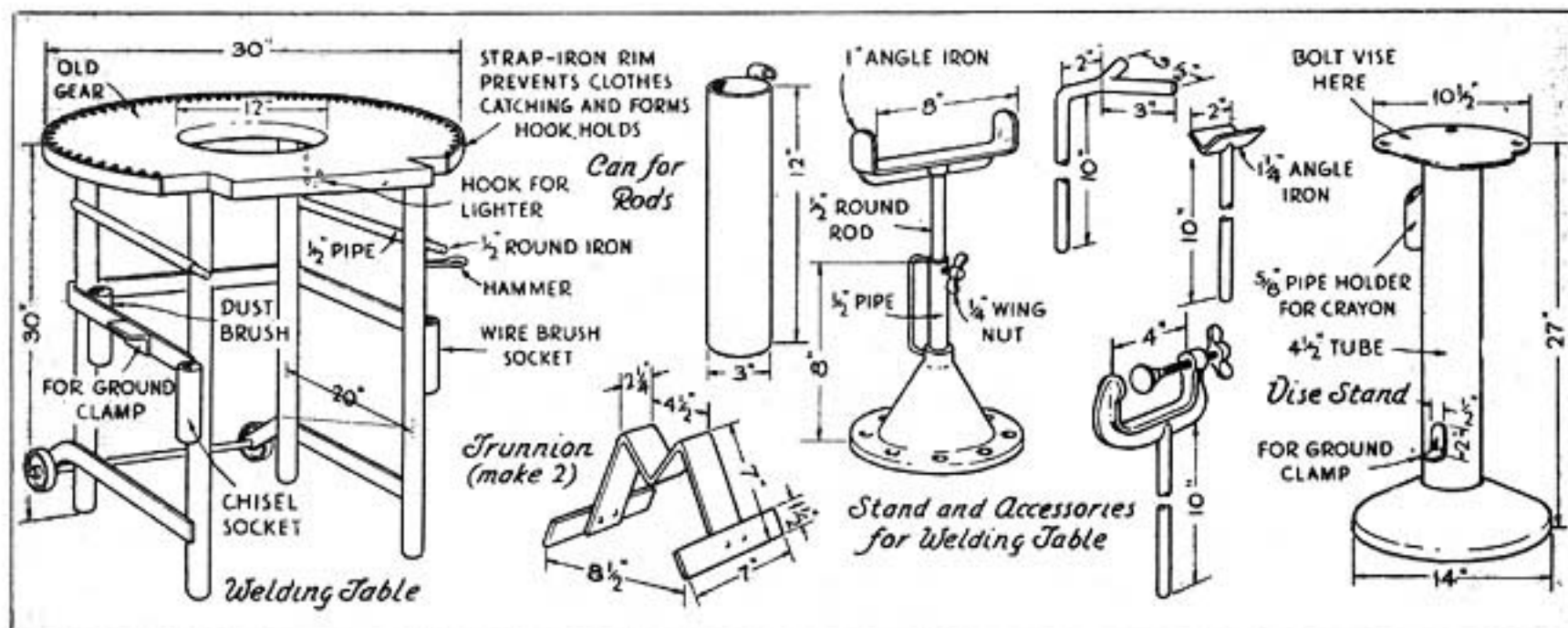
stand for propping work in an oblique or vertical position consists of a short $1/2$ -in. pipe welded in an iron bell and provided with a wing screw for clamping the various holders in place. One holder is T-shaped, the cross bar made of 1-in. angle iron with the ends turned up for catches. Another holder terminates in a short angle iron forming a V; and a third is forked horizontally. The one with the carriage clamp is valuable for many jobs. For cylindrical work, the trunnions, which are bent from $1/4$ by $2\frac{1}{2}$ -in. flat stock, are handy.

An added convenience is the vise stand, used in conjunction with the table. The base of this one was made from a junked manhole cover, and the column from scrap tubing. A piece of $3/16$ -in. sheet stock welded to the top and pierced with holes for bolts carries a machinist's vise with jaws about $4\frac{1}{2}$ in. wide.

Continued next page.

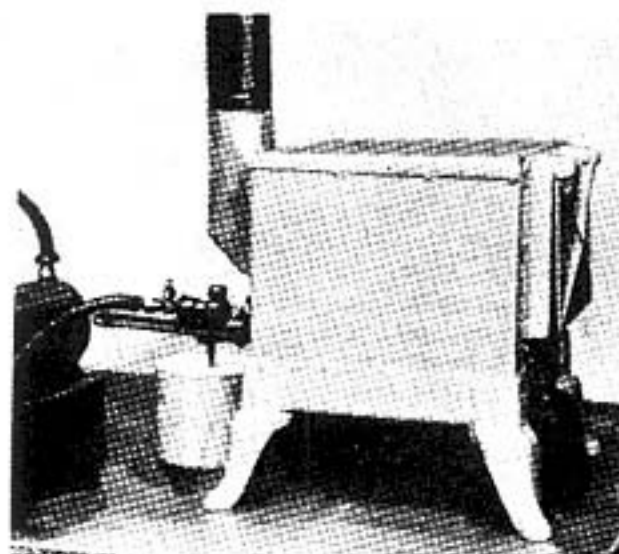


Welding table and various accessories. Note the telescoping handles for moving the bench



How the table is made with an old, thin gear for the top; sketches of a variety of work-holding devices; and a portable stand to support the vise

Tempering and Melting Furnace for use with DIESEL TORCH



A side view of the furnace with the torch in position. A salvaged compressor from an auto-wrecking concern supplies the air

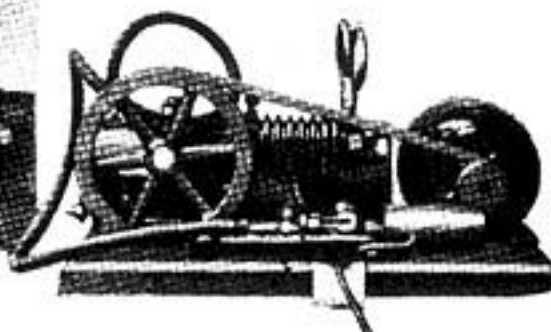
By W. C. CHENEY

Popular Science 1936

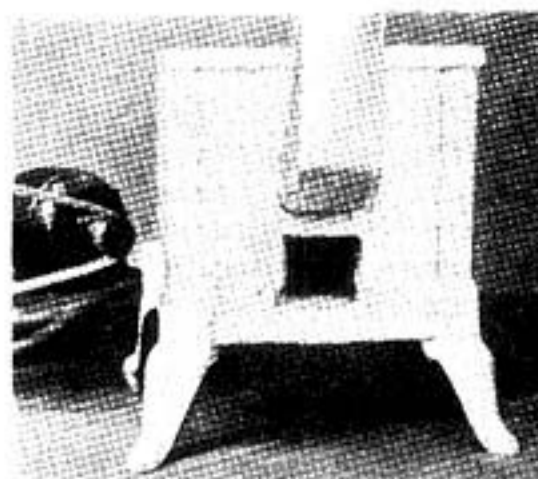
A TEMPERING and melting furnace that uses Diesel oil for fuel may be constructed for less than five dollars by following the accompanying illustrations. Although intended primarily as an annealing and tempering furnace, it may be used also for smelting samples of ore and for making small iron, brass, and aluminum castings when used with the air Diesel oil torch described in last month's issue (See Page 495)

Because of the construction, whatever is placed in the furnace is heated by indirect heat, which has obvious advantages. When used with the air Diesel torch, the heating chamber may be adjusted for an oxidizing, carburizing, or neutral heat, all of great use in shopwork.

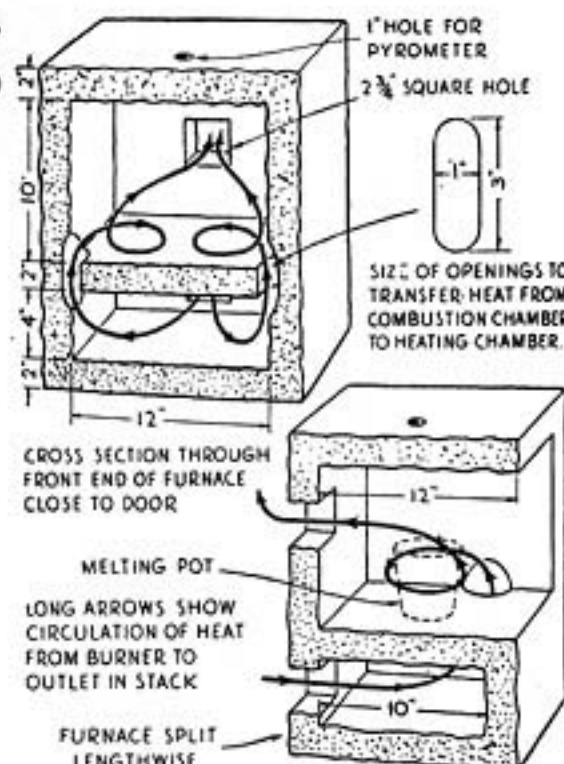
The dimensions may be changed to suit special conditions, but the furnace shown gives good results for a wide variety of work. A



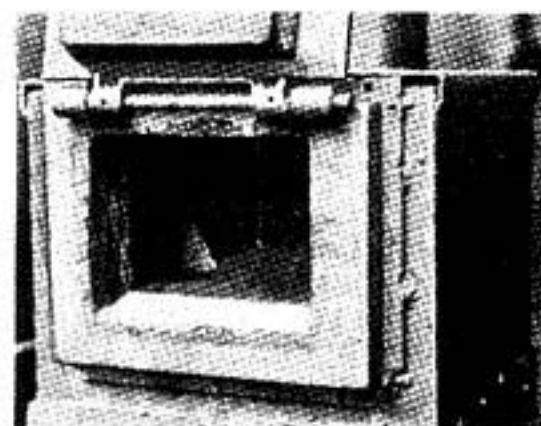
damper may or may not be used, depending upon the type of work, but when the furnace is used for smelting or melting metals, a



Rear of furnace with opening for torch, and, view into heating chamber from front



Two cutaway diagrams of the furnace showing method of arranging the slabs of fire brick



damper is of considerable value. The door must be faced with fire brick, and all brick joints must be tight, with high-temperature cement between all joints. The fire brick and

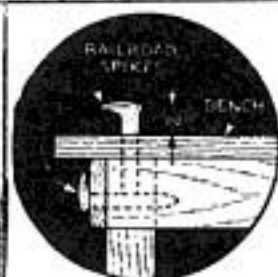
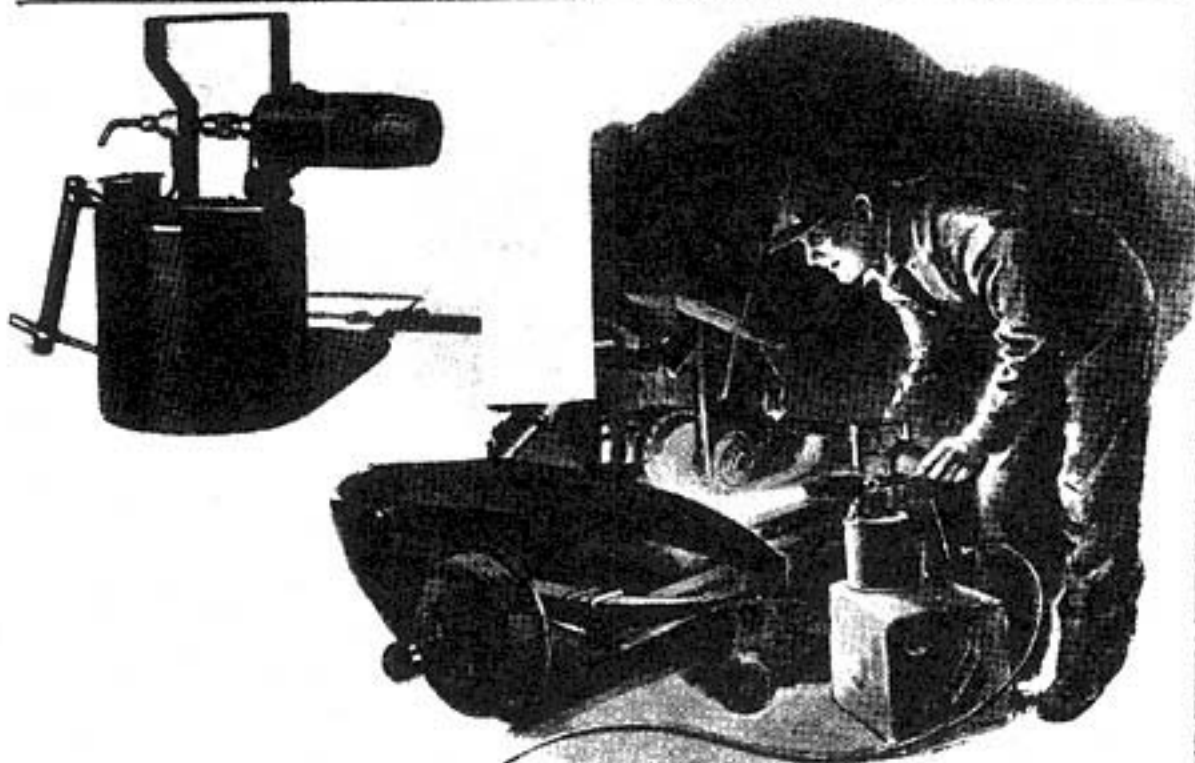
suitable cement may be obtained from large building material dealers or from furnace repairmen.

The furnace is covered with light sheet iron, and the joints are spot welded. Sheet iron is used also for the stack, being welded and extended into the outlet opening of the furnace.

The brickwork is made from slabs of fire brick, sawed and filed or ground to fit. The door may be made from a piece of $\frac{1}{8}$ -in. plate or, as in the one shown, purchased from a local stove works. In either case it must be faced with fire brick. The openings from the combustion chamber to the heating chamber

should be placed as shown and in the same proportion for even heat distribution.

If there is no convenient air supply to operate the torch, a small compressor may be rigged up as illustrated at a moderate cost.



Large Spike Serves as a Tiny Anvil

SET in a hole directly over a leg of your workbench, a railroad spike makes an excellent anvil for small work. Saw off the point of the spike, chisel a hole to a depth that will leave about 2 in. of the spike above the surface of the bench, and cut a hole in from the front of the leg so that another spike can be driven in to support the end of the vertical spike, as indicated in the drawing above.—EDWARD RAMAGE.

SHOPMADE

Popular Science 1936

Air-Diesel Torch

GIVES INTENSE HEAT

By W. C. CHENEY

FOR safety, economy, ease of construction, and intense heat the air-Diesel torch has much to recommend it. The one illustrated uses about 1 gal. of Diesel or stove oil an hour, and the air supply may be almost anything that will supply a pressure of from 40 to 300 lb. per square inch through a $\frac{1}{16}$ -in. hole. The torch carries no fuel under pressure, has no insurance restrictions, cannot explode, starts without generating, and if the heat is confined, will melt cast iron. The flame may be regulated from a small flame for heating a soldering iron to a blast 3 ft. long.

In the illustrations above, the fuel tank is attached directly to the torch. For general use,

this is a convenient arrangement, but the torch may be used separately, if preferred, and a suction hose provided to supply the fuel. When the burner alone is used in this way, it will lift the fuel about 4 ft., although for best operation the fuel supply should be only slightly below the burner level.

Whether the torch is used separately or not, the burner construction is the same. The drawings give the details. Best results will be obtained if the dimensions of the mixing valve and burner are followed exactly; dimensions not noted on the drawing, however, are not vital and may be left to the judgment of the maker. The tank is a matter of

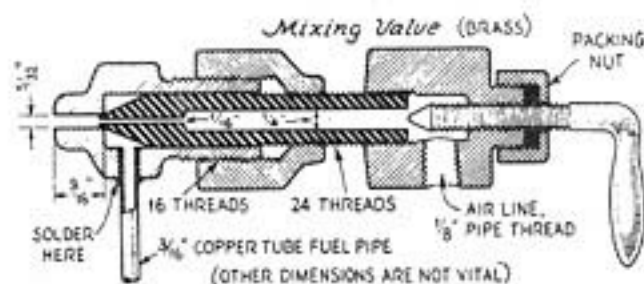
choice, and no sizes are given for it.

The mixing valve of the burner makes an efficient paint-spray gun for use on plain work.

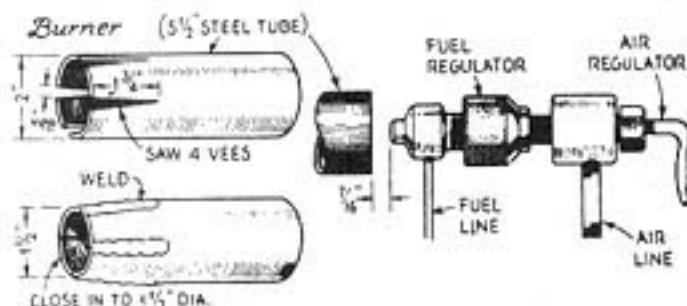
To light the torch, unscrew the fuel valve about two turns, light a piece of scrap paper, crack the air valve, and when a heavy white fog starts from the burner, shove the burning paper into the back opening of the burner. Regulate the air and fuel so the flame burns with a slight orange-red tinge. This gives the greatest heat. Keep the burner well back from the work. Most beginners make the mistake of trying to crowd the burner too close to the work.

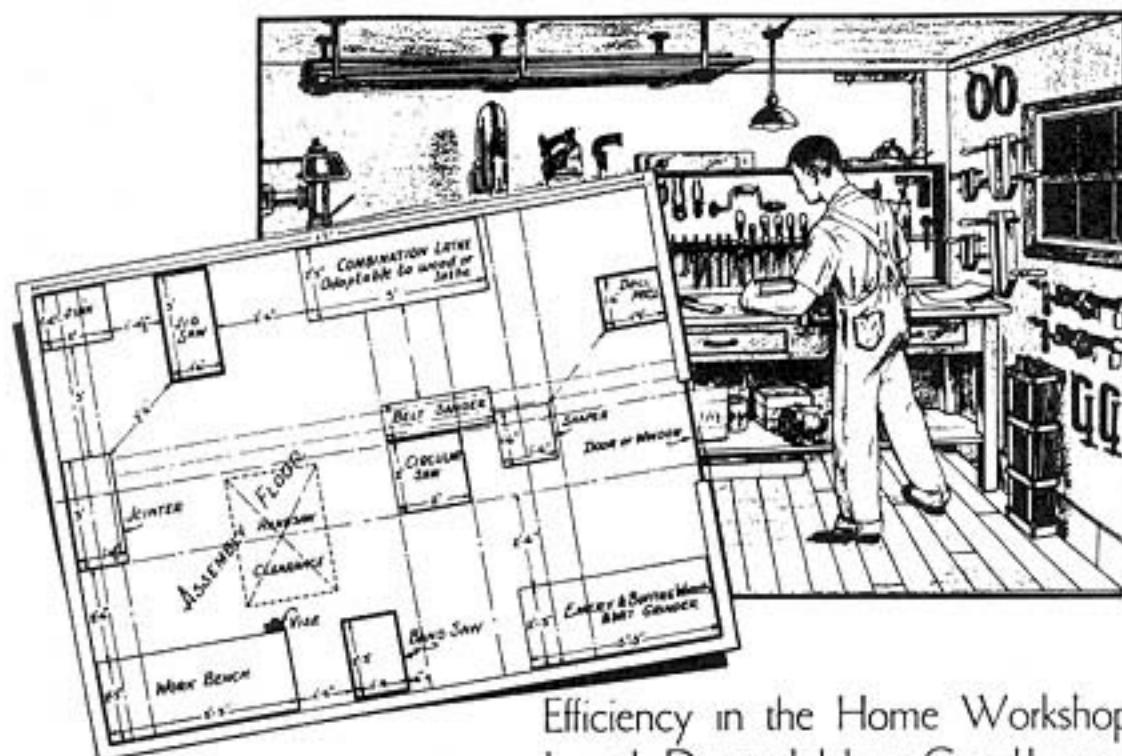
To increase the flame, first turn on more oil and then more air. To decrease the flame, first cut down on the air, then reduce the oil. If this method is not used, the torch is likely to blow out, and it will have to be started all over again.

If the mixing valve becomes plugged, open the fuel valve two or three turns, hold your finger over the outlet of the mixing valve, and turn on the air. The dirt will be driven out through the suction line.



Cross-section view of the mixing valve, sketch of burner tube, and diagram showing space to maintain between them





Efficiency in the Home Workshop
Largely Depends Upon Good Layout

PLANNING A WORKSHOP

By Forrest H. Wells

THE HOME CRAFTSMAN 1937

PHOTOGRAPHS and descriptions of individual shops are frequently published, but the great majority convey no helpful information to the man who must lay out his shop in a room differing in shape, area, and incidental handicaps. Any special solution, applied to a single case, is not apt to be of much assistance elsewhere. However, basic principles covering the layout of all shops do exist, and their proper application will make the most of any room, whatever its size, shape, or proposed equipment. The attached sketch is purely illustrative; the principles discussed apply with equal force anywhere.

There is much disagreement as to which power tools are the most valuable to the home craftsman. As a matter of fact, the selection of machine tools is always a personal problem, and each answer depends upon the skill possessed by the individual and upon his intended kind of work.

For average work and for the beginner, the most essential equipment includes the workbench, the circular saw, the band saw, and the sander, in the order named.

Whatever machines are purchased and whatever the order in which they may be acquired, it is of the utmost importance to lay out all the shop

floor space at the very beginning so as to allot places for all additional equipment concerning which there is even a faint hope of eventual purchase. It is inconvenient, expensive, and discouraging to be ripping out shelving, changing wiring or pipes, and moving machines and material racks every time a new piece of equipment is acquired. Space eventually reaches a high premium in ninety-nine shops of every hundred, and the only sensible course is to allocate all the available space from the start, using a measured drawing of the room, and accounting for every door, window, pipe, and column. This course also permits a wiring plan which will incorporate all future additions without altering the initial arrangements. Modern practice requires not only general light for the shop as a whole, but an individual light shining on the point of cutting at each machine. If a double outlet is planned for the proposed location of each machine, at a height of about four feet above the floor, both motor and light may be plugged in without festoons of cords.

In the plan sketch, only one opening in the wall is indicated, and it is inserted only to illustrate a principle connected with the mounting of the circular saw. In practice, workshops have to be fitted into rooms as they are found, taking windows and doors as they come. So far as possible,

machines should not be placed squarely in front of windows, as the wall space just behind a machine ought to be fitted as a tool rack. A window in this spot also exposes the machine to the direct beat of rain, is hard to get at for opening and closing, and usually gives a glaring light. These disadvantages apply with especial force to the workbench, in spite of the common practice of placing it directly across a window.

The whole secret of every successful shop plan is the provision of a clear path by which stock can come to each machine, feed through it, and come away. In all cases the path must not end at a wall so close that full-length stock cannot get into it on the one side, or get out on the other, as the case may be. Where shelving or other machines stand in any path, they must be low enough for the stock to pass above them, except that in rare cases a stock path may tunnel through the stand of a high machine. The process of planning any



shop resolves itself into the provision of these paths, and they in turn determine where each machine must stand.

We therefore begin the allocation of floor space by considering the circular saw, whose operation demands greater clearance on all sides than is the case with any other machine. The correct placement of this saw is the foundation of any successful plan. In the home workshop, one is seldom called on to rip stock of a length greater than ten feet; allowing for that figure as a maximum, we tentatively reserve the space in front of the saw blade for a distance of ten feet, taking a strip at least as wide as the table. Stock takes as much room to feed out from the rear of the saw as is needed coming in, so we also reserve a corresponding strip extending ten feet behind the blade.

At the sides of the saw table we reserve an area for stock being mitred or crosscut, reaching no more than six feet on each side of the blade. To the area thus reserved for the passage of stock there must be added a walkway around both front corners of the saw table.

The above requirements thus call for a cross-shaped plot in a room at least $12\frac{1}{2}$ ft. by 21 ft. with the saw blade at the exact center. So long a room is seldom available, and the average user must reconcile himself to working his saw at greatly reduced capacity. However, if the saw can be set in front of a window, door, or scuttle, as in the sketch, the opening will receive the outfeed and allow a greatly increased capacity. If the shop has no such opening, and is less than seventeen feet long boards much over six feet long cannot be ripped. It is not usually practicable to set the saw in the exact center of a small room, as to do so would leave no room for an adequate workbench or for an assembly floor.

Logic dictates a specific position for the workbench. To set it against an end wall would usually encroach upon space reserved to the circular saw. To set it anywhere to the rear of the sawblade would entail a great many extra steps as the worker passed between sawtable and bench, a journey made many times during the course of most projects. Of the two remaining possibilities, to use the one to the left of the saw would put the vise into a corner, drastically reducing the length of stock the vise could receive. Except in a very large room, it is scarcely possible to put the bench otherwise than where shown in the sketch. There is a further advantage in this location. When a worker is handsawing stock in the vise, he stands to the left of the workbench end by about eighteen inches. Moreover, when he bends over for close inspection of his work, he requires a considerable free space behind him; in fact he will bump anything which stands within $3\frac{1}{2}$ ft. of the vise jaw at full opening. Unless a room of great size is available, experiment will prove that it is practically imperative to have the following clear areas adjoin or coincide in whole or in part: (1) the stock space for the infeed of the circular saw; (2) the worker's pathway along the front of the workbench; (3) the above-mentioned clearance for hand sawing.

The arrangement sketched not only concentrates the foregoing areas, but by the addition of certain operating spaces obtains an assembly floor roughly 7 by 8 ft. in the clear. The absence of such an area for assembling projects will cripple any shop. The space must be provided, and the best possible location is in front of the workbench.

In addition to the usual woodworking vise, the bench should be provided with one suited to metalworking. This should be set well toward the right end of the bench, and should be fixed on a peg mount so that it may be removed easily whenever a project requires clearing the entire bench top. The bench should be as long as the space available will permit, and in no case shorter than five feet. The width must not be less than two feet or handsaws will bump the wall when cutting stock in the vise. Shelves and tool racks should fill the wall above the back of the bench. The bench top should be as wide as possible. This dimension will vary with the stature and reach of the user; 2 ft.-4 in. is a good average figure.

It must be remembered, too, that various machines differ widely in the distance between their cutting points and the floor, a factor which makes it possible to feed stock to and from certain machines by passing it over the top of others. This expedient is particularly needful in the cases of the jigsaw, the bandsaw, and the drill press. All of them may be called upon to operate at the extreme end of a long piece of stock, and the saws in particular require that the stock be swung across a wide arc for curve cutting. They require in front a fan-shaped clearance of such dimensions that the only practical solution is to mount them with their tables high so that stock may be swung back and forth above the tops of the remaining machines. It is for this reason that the tables for the foregoing three ought to be set at a height suited to a *standing* operator.

Naturally these high machines interfere with each other, and it follows that they must be placed as far apart as possible with no two against the same wall. To emphasize this requirement they are sketched with especially heavy outlines. The needs of the bandsaw are the hardest to satisfy. In addition to the usual fan-shaped clearance in front, the use

of the bandsaw to put a curve down the edge of a long board demands the same clearance in front of and behind the blade as if it were a rip-saw. To work stock of maximum length the bandsaw must be set at the midpoint of one of the longer walls. The site next the bench is chosen, as the trip between vise and bandsaw is a frequent one, and their close juxtaposition is an advantage.

In the arrangement sketched, full advantage is taken of the high table of the bandsaw. The plane of infeed lies above the grinding and polishing group, and the outfeed is above the workbench. When a cut is run across the end of a long board, the stock swings freely above the saw-sander-shaper group. The operator's standing space in front of the blade coincides with an area already cleared for circular saw stock, thus enabling duplicate use to be made of the same space. Likewise, the standing space to the right of the bandsaw blade coincides with the operator's walkway around the adjacent corner of the circular saw. Such combination uses of the same empty space are the very essence of efficient shop planning.

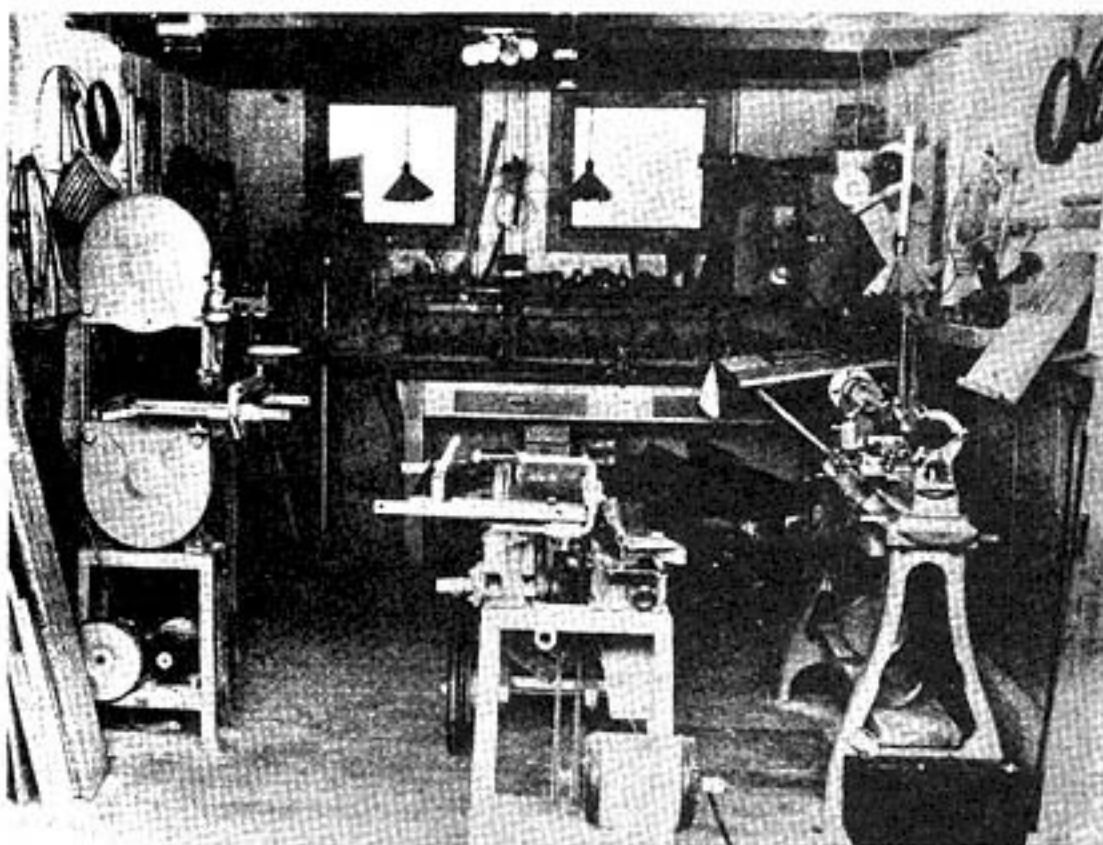
The high table of the jigsaw enables it to swing stock over the tops of all adjacent machines, provided the lathe is driven from behind or below the headstock. The lathe should be so mounted that its highest part (usually the cone pulley) lies below the plane of the tables of the three high machines. A comfortable position for most operators will bring the lathe well below this limit. Note that jigsaw, bandsaw, and drill press all have standing room in front and on both sides.

A lathe takes up not only the wall space immediately behind it, but it must also have enough clearance at the right end to allow the tailstock to come off when inserting or removing the slide rest. If outside face plate turning is contemplated, the left end must have at least $2\frac{1}{2}$ ft. clearance. As a result, no machine demands as much wall space as the lathe, and its logical location is therefore the middle of the remaining long wall, across the room from the bandsaw. The plan allows floor space for the largest lathe commonly found in home workshops; it would be poor policy to allot only room enough for a small lathe and so be unable to expand in

the future. The right end of the lathe is set just clear of the shaper path; the clearance at the left coincides with the operating space around the jigsaw.

The small shop sketched is purposely restricted to the least dimensions within which an adequate shop may be set up. As shown there, the lathe trespasses upon the stock path to the left of the circular saw; however, the requirements of ordinary cross-cutting and mitering are satisfied with the four feet still available to the left of the sawblade and six to the right. If a longer room is available the lathe would be better placed if moved clear of the saw stock. Similar considerations prevent the inclusion of a lathe devoted exclusively to metal working. The sketch is by no means intended to represent the ideal shop, but merely a workable minimum in which the basic principles of shop planning are exemplified. A bigger room would furnish several sites for a metal-working lathe, with little change in the basic plan.

Certain machines may conveniently be operated closer to the floor than the table of the circular saw. This permits their location inside the cross-shaped area nominally reserved for saw stock. In such installations it is of course essential that every part of every such machine lie below the lowest plane to which the saw table can be set. An example of this class is the sander; note that it is placed to the left of the saw table which tilts to the right for angle sawing. The jointer is very often given this place alongside the circular saw and on the same mount, but the sketch assigns the position to a belt sander because this machine comes into play to finish off the work of practically every other machine; hence a position as near the center of the shop as possible will in the long run save miles of steps. The position adjacent to the saw is particularly convenient for rounding the edges of stock lightly so that there will be no knife-edges where varnish or enamel would speedily wear off. With the arrangement shown, this step is carried out as each piece comes from the saw. It should also be noted that a small jointer takes a light motor but both saw and sander demand the heaviest motors in the shop. There is logic and economy in placing them as sketched and belting to the same



A striking example of good workshop planning is illustrated here in the "before and after" photographs of Dick Cole's Los Angeles workshop. The old garage at the left became the modern workshop shown above.

motor.

Sanders which incorporate a belt and a disc sander in the same machine require to be set in the middle of an open space so that the operator may work at either side. Desirable as these machines are, the very small shop lacks the floor space for mounting them, and in the sketch only a belt and stroking sander is shown. A disc sanding attachment should be procured for the lathe, or if space permits, a disc sander may be given its own stand.

In locating the shaper, the tilt of the saw table must be considered. In order to keep the shaper table out of the way of stock being ripped at an angle, it may be necessary to set the shaper over into the sander path, in which case the shaper must go even closer to the floor. Other things being equal, the nearer the shaper stands to the center of the room the better, since whichever path is shorter, infeed or outfeed, sets the maximum length of stock which can be worked.

The emery and buffing wheels and the wet grinder must be mounted clear of the path of shaper stock, and the table on which they stand must lie below the plane of that path.

The table space left clear for shaper stock will be extremely useful for whetstones and slipstones. It is suggested that the above three machines

for grinding and buffing be driven from a countershaft, preferably under the table top. It has been previously mentioned that the circular saw and the sander should be driven from one motor. With these exceptions it is recommended that each machine be given its own motor to save friction and to avoid a multiplicity of belts and shafting. In fact certain machines practically demand an individual motor. If the remainder cannot all be provided with motors, one or more should be fitted with rocker mounts and shifted from stand to stand as need arises.

The jointer requires as much clearance for outfeed as for infeed, and if not placed on the same stand as the circular saw it should be set at the midpoint of the remaining free wall. In either location it will handle stock up to six feet in length without end-for-ending. This is adequate for ordinary projects; when more clearance is needed the jointer may be rolled temporarily to another location—a change which is easier if the jointer is on its own stand and not sharing one with the circular saw. The height of the jointer should be such that it will not interfere with saw stock. At the same time, stock being jointed must pass above the sink and above the bench top. Fortunately the natural relative heights of all

these objects permit the foregoing arrangement to be effected without difficulty. These examples demonstrate how great is the inter-relation between machines in the small shop and how the placement and operating height of each depends on one or more of the others. This is a major reason for planning the shop as a whole from the very beginning, in order to iron out interference on paper rather than by exhaustive trial and error renewed each time another machine is purchased.

If a high speed hand router is available, it is most conveniently used on the regular workbench with some sort of overhead suspension by which it may be slid or swung out of the way when not in use.

Where machines stand against an outside wall it is sometimes possible to discharge their dust and shavings into outside bins. In the same manner one or more scuttles may be cut at floor level for the exit of sweepings;

such a scuttle is especially valuable near the vise.

No storage cabinets or tool racks are shown; these must be designed to fit available space in the individual shop and should only be planned after all machines are provided for, using whatever niches and interstices may remain. A great deal may be done with drawers and shelving inside the machine stands, with the added advantage that all weight stowed there adds to the steadiness of the machines. Tool racks with clips, hooks, and slanted shelves suited to individual tools should be placed behind the workbench and lathe. Bar clamps should be hung on wall racks handy to the assembly floor.

When floor cabinets or sets of shelves are located under the swing of stock of any machine, their tops should lie at least a foot below the plane of that swing. Objects are certain to be set on top of such cases, and without ample headroom they will

inevitably get knocked off by a piece of stock.

It may be observed from the sketch that at each and every machine the operator has a clear standing space of at least 2½ feet. Under no circumstances should less clearance be allowed, no matter how small the shop; it would be wiser to delay purchase of some of the equipment if sufficient operating space is lacking.

If the room available has dimensions greater than the sketch, the first use which should be made of the margin is to plan for a saw with a bigger table than 2 ft. by 2 ft. Additional margin may then be expended in increasing the separation of machines so as to give wider working passages. The general arrangement shown in the sketch will serve for an efficient tentative plan for any oblong room, regardless of dimensions; while the principles set forth in this article apply to the planning of any shop, regardless of either size or shape.

A SURVIVAL WORKSHOP

By Bill Abreu

The need for some form of workshop is necessary for survival and self-sufficiency. A self-sufficient workshop is one where you can construct necessary equipment and use and even build your own tools without being dependent on manufacturers.

To begin with you must find a good place to set up your shop. A garage, of course, is a good location; however, outside in your backyard is even better for setting up a small wooden shed. The shed should be sturdy and built to keep out rain and wind. Also, the door to it should have a strong lock to keep out thieves and neighbors who are in the habit of borrowing tools without asking. It is possible to buy a ready-made tool shed at the department store, however, they are relatively flimsy and lack shelves and benches.

Power tools are preferred to hand tools for their speed and ease in effort. However, the hand tools come in most needed when there is little or no form of power. It is for this reason that your shop should have both hand tools and power tools. THE SURVIVOR lists many fine hand tools which can be inexpensively made and also many power tools which run on wind power or another form of energy aside from electricity. But, if you are determined to use electric-driven tools, then a windmill connected to a large motor can be utilized. A motor and a

generator are built almost exactly the same. In other words, a motor can be used as a generator and a generator can be used as a motor. If the motor is well-lubricated and the wind fairly strong, depending on the size of the motor, a sufficient amount of energy can be produced. If there is still not enough energy to run the power tool it helps to connect a step-up transformer to the circuit and to use only low-voltage tools.

Another form of power can be derived from home-made storage cells. Actually, a storage cell does not produce electricity, it

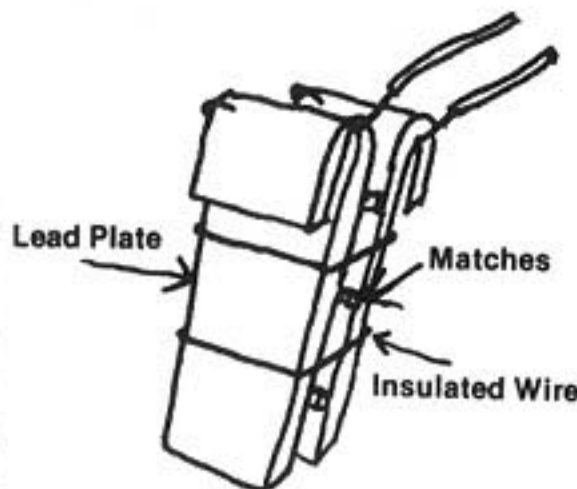
two lead plates (about two inches wide and five inches long) tied together with insulated wire or strong string. Between the two lead plates should be matchsticks so that they will not touch. The tops of the plates are hammered over the bare ends of wires to make two contacts. These two plates are then placed in a jar of hot water. With the water should be mixed one heaping teaspoonful of biocarbonate soda. To charge the cell, the wires are connected to the contacts of a six-volt battery (though higher electrical sources can be used) for five minutes or more. The cells can release up to six volts, however, the voltage can be increased if a series of cells are connected together.

Also important in the workshop are tools for reloading ammunition and for repairing firearms. Because weapons are often important in survival, it is wise to keep tools to repair and possibly even build weapons and firearms.

Though many people are uninterested in storing and preserving food, it is wise not to overlook the possibility of using your work shed to store food. If you live in an area with warm weather then it will be possible to store only non-perishable foods, such as sugar. If the weather is cold, then you can store fruits, vegetables, meats, etc.

Equipment for working with metal is also important in your survival workshop. On page 1016, Volume 3 of THE SURVIVOR is a description of a small furnace which can be built. This furnace would be especially helpful if you

STORAGE CELL



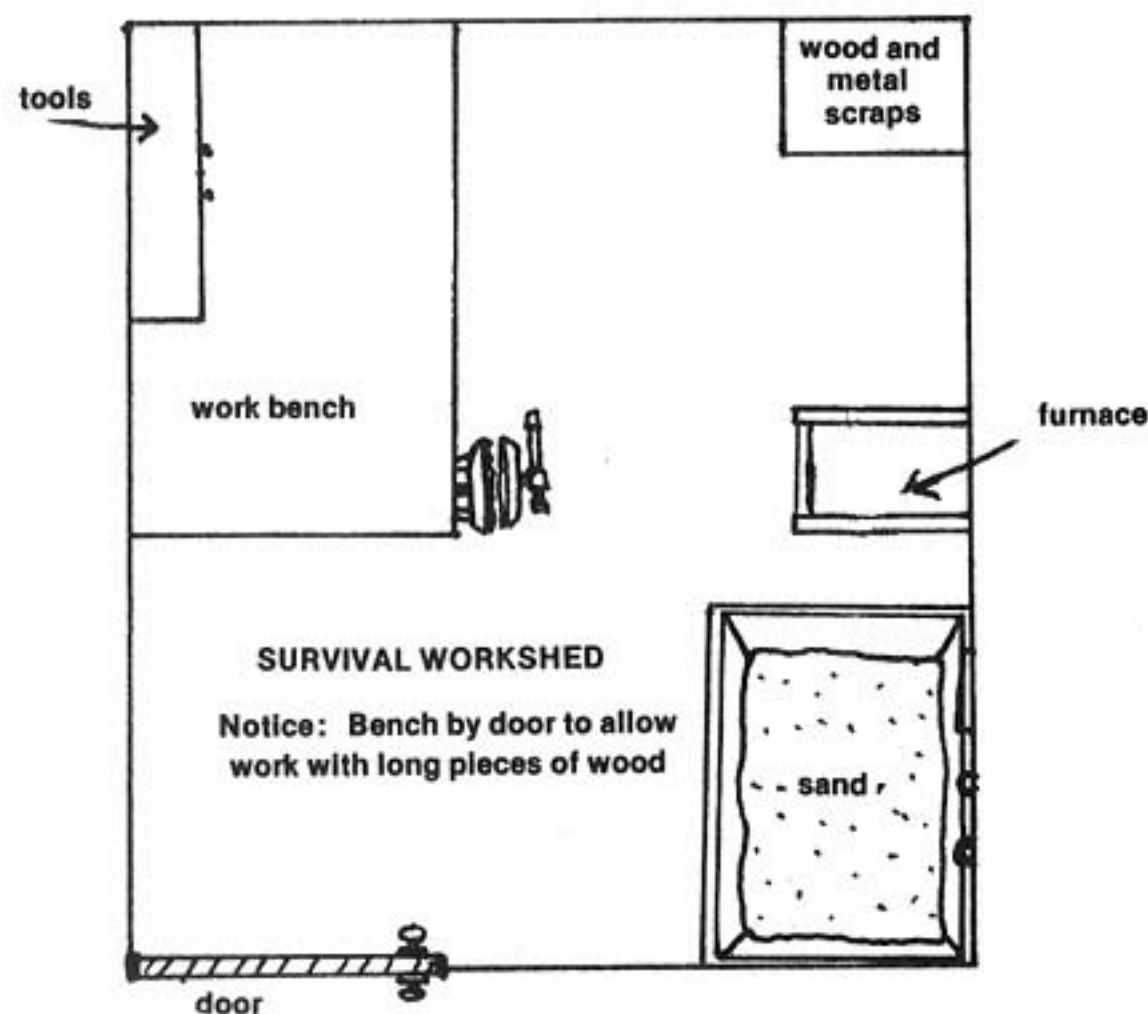
merely stores it (as the name implies). A storage cell can be constructed by using

occasionally need to melt down metal to make parts for machines, guns, etc. The foundry area in Volume 1 of THE SURVIVOR on page 58 will help to do this. It is desirable to make a somewhat scaled down version of this foundry shop to allow more space for tools and machines. Along with your foundry area should be kept an abundant supply of scrap metal and sand. Aluminum is best obtained from old tin cans and tv trays, whereas copper pipes and brass fittings can provide for other sources of metal scraps.

A workbench is a necessity for a workshop and can be built from the article on page 145 of Volume 1 of THE SURVIVOR. Sturdy woods, such as oak, should be used in its construction. Maple is also an excellent form of wood, but woods like elm and sycamore, which have a tendency to warp, should not be used.

A strong vise is one of the most important tools in a workshop, so it is advisable to purchase a very sturdy one or, if possible, to construct one which will be firm and serve to hold your work tightly. The workbench should, of course, be secured to the ground or floor to keep the work from moving and enable you to make more accurate cuts and drills.

A supply of nail, screws, and other small hardware items should be kept in your shop. Each should be kept in their own easily accessible container, with each different size separated. Actually, this should go without saying, however, many



people will haphazardly store these small and seemingly insignificant items. Then, when the time comes they are needed, they prove to be extremely important in a particular project.

Throughout THE SURVIVOR are many ideas and projects for workshops which

can be incorporated in your own survival workshop. Some of these projects may be just useful while others may be necessary. But, whichever they are, all will help you to better understand the need for self-sufficiency.

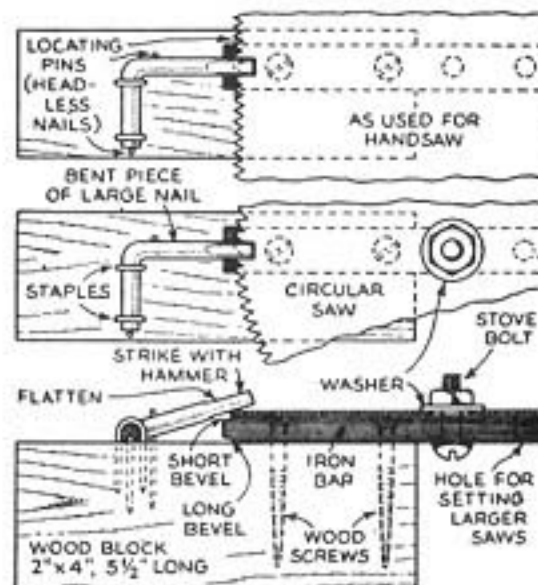
SAW TEETH QUICKLY SET WITH SIMPLE DEVICE

Popular Science Monthly, October 1936

FOR giving a uniform set to the teeth of circular and other saws at the time they are filed, a surprisingly simple fixture can be made as shown below from a few scraps of wood and iron. With it, the unpracticed hand can do a good job of setting, and do it more rapidly than with some of the more commonly used setting tools. The device is gripped in a bench vise while being used.

A piece of 2 by 4-in. block, 5 in. or more in length, will be suitable for mounting the metal parts. These will include a piece of flat or square iron bar, $\frac{1}{8}$ by $\frac{1}{2}$ in. or more in size, and 1 in. longer than half the diameter of the largest circular saw to be accommodated; a short stove bolt with nut; one washer slightly thicker than the circular saw and of an outside diameter to fit snugly inside the hole in the saw; another of larger outside diameter; and a large nail or spike.

With a file, bevel off the end of the flat bar to the angle desired for setting—usually from 10 to 15 deg. Hold the circular saw against



Top and side views of the fixture, which enables saws to be set speedily and accurately

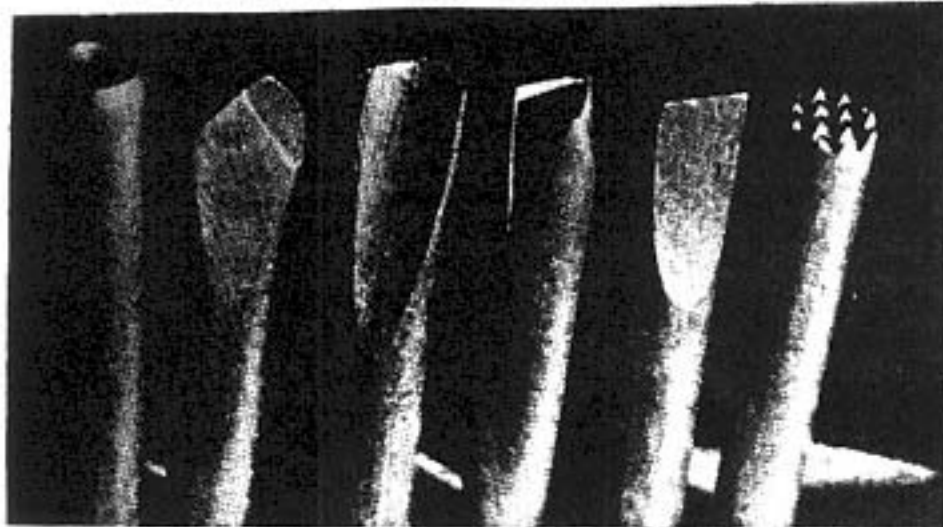
the bar in the position shown, with base of teeth at top of bevel, and scribe a circle inside the saw hole. In the center of this circle, drill a hole through the iron bar to receive the stove bolt, not too loosely.

A piece of the large nail, filed slightly flat at one end, bent to a right angle and attached with staples and nails as shown, rests upon the saw tooth and, when struck with a hammer, quickly bends each tooth in turn to the angle of the bevel on the iron bar. For use in setting handsaws or band saws, two additional locating pins may be driven into the wood block as indicated in the upper sketch.

Each time the same circular saw is filed, the bevel on the flat bar may be filed slightly, to adjust it to the shortened radius of the saw. Fifty teeth or more a minute can be given a smooth, uniform set in this way. Ripsaws will require a longer bevel and therefore a different flat bar. If, however, the bar stock is stiff enough (not less than $\frac{3}{8}$ in. in thickness), one side can be beveled for rip and the other for crosscut teeth. Reversing is then accomplished by removing the two wood screws.—H. K. RANDALL.

The Humble Nail

BECOMES AN EMERGENCY TOOL

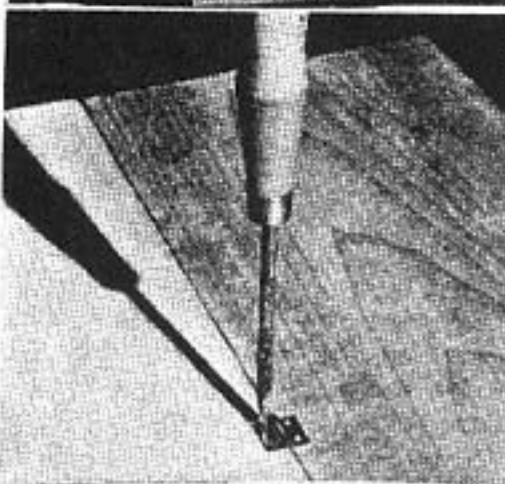


Shown above, enlarged, are only a few of the emergency tools made from the common wire nail. Left to right, they are: dapping die and rivet header, drill, crescent chasing tool, V-tool for chasing, extra-small screwdriver, and background or stippling tool.

WHEN the lack of a special small tool means delay until that tool can be purchased, it is sometimes possible to enlist the common nail as an emergency tool. One of the most practical nail-tools is the wood bit, made up in a special size for a single job. The size of the nail to be used will depend on the size of the bit required. The head is cut off so as to form a straight shank. The point is flattened with a few hammer strokes to fish-tail the end, and the new point is formed with the aid of a grindstone. It is essential to grind a bevel on each side of the point for clearance. The resulting tool will answer the purpose of the average emergency job wherein it is necessary to drill a few small holes either by hand or in the drill press.

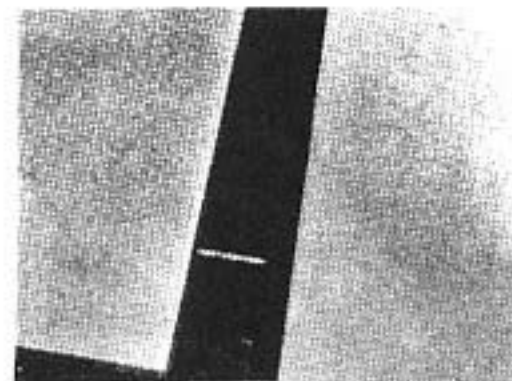
The scratch awl, or scriber, is another tool that may be made from a nail. Here again the nail head is removed first. Requiring only a sharply pointed end, the scratch awl is the easiest of the group, and is made entirely on a grindstone. If a handle should be made for this tool, the result will be a tool that may be used for marking metal or for making holes to start very small screws.

The brad awl and screwdriver are made from 8d nails. The nails are driven into handles before the heads are cut off with cutting pliers or a hack saw. The tips are shaped on a grindstone. Small screwdrivers made in this way for installing diminutive hinges and similar jobs should have



their tips slightly hollow on each face.

Metal "dowel" pins are fasteners that are used to assemble pieces to form panels. An example is shown in the bottom photograph. These pins are made from 10d nails by cutting them in half and grinding a point on each end to form a pin about $2\frac{1}{4}$ " long. To fasten wood together with these pins, small holes are drilled in the edges of the stock to be joined. The pins are inserted and with the aid of bar clamps the wood is forced to-



gether so as to drive the pins in place.

Whenever work on soft metals is being done by the home craftsman special homemade tools for chasing can be readily contrived. There is a straight tool which may be made up in any size to be used for repousse work. This tool is shaped like a screwdriver and the tip is then slightly rounded to prevent the tool from cutting the metal.

Dome-shaped dapping tools for raising metal are procured when a nail is rounded at the point and finished off with emery cloth. This is used to form small concave or convex surfaces. A cup-shaped tool can be made to serve as a dapping die and a rivet header.

The crescent tool is made with the aid of a small rat-tail file. It will come in handy for scalloping the edges of ash trays or other metal dishes. The V-shaped tool is made with a small three-corner file. This tool will also find many uses for decorating metal.

These are only a few of the possibilities for the use of the nail as a tool for metal and wood, but it is important to realize that they cannot possibly replace tools made specially for these jobs.

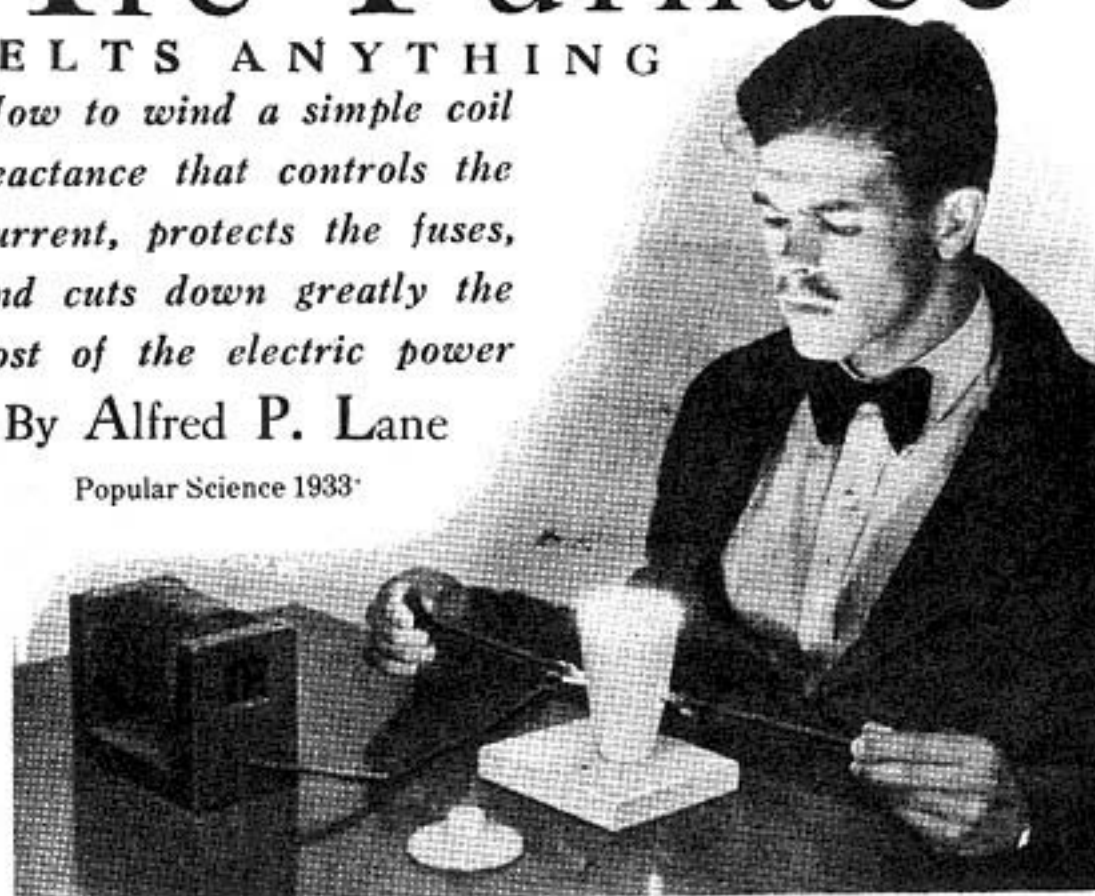
Arc Furnace

MELTS ANYTHING

How to wind a simple coil reactance that controls the current, protects the fuses, and cuts down greatly the cost of the electric power

By Alfred P. Lane

Popular Science 1933



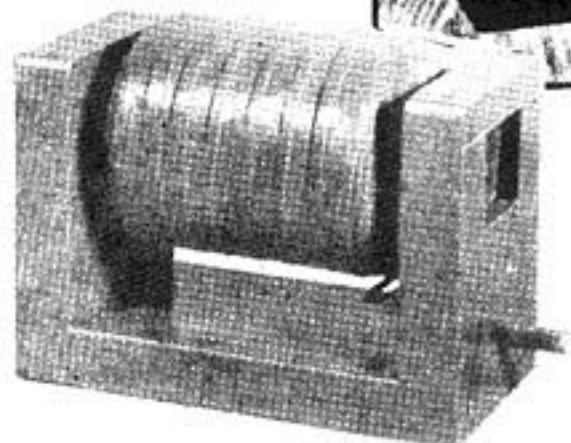
Operating a small arc furnace with a reactance that is as effective as two 600-watt electric grills connected in parallel. It is practically as serviceable as a step-down transformer

H EAT so terrific that no known substance is able to withstand it for long can be developed in your home laboratory with nothing more than a pair of electric light carbons, a small crucible, and some means of controlling the flow of the electric current from the house mains through the arc.

Most electrical experimenters attempt to use an old toaster or electric grill in series with the arc. This works all right, but the current flow is limited to three or four amperes and is greatest when the carbons are in contact and the arc is producing the least amount of heat. Adding another toaster or grill in parallel with the first one doubles the current through the arc, doubles the cost of operation, and still is open to the objection that the current flow is greatest when the arc is least effective.

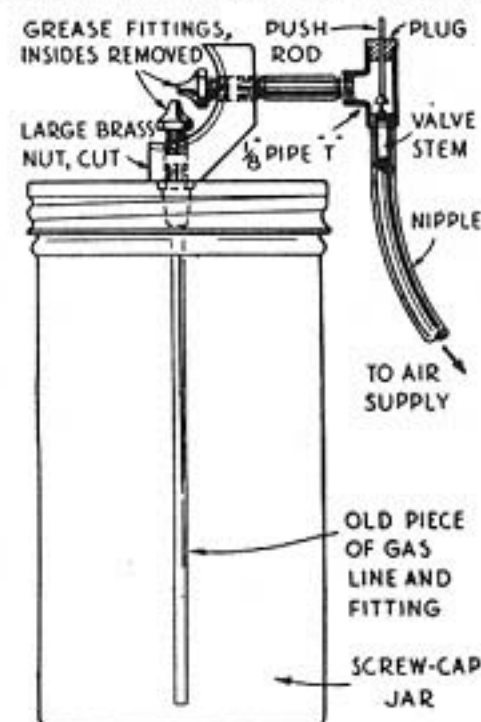
The difficulty is that a carbon arc, operating on the ordinary 60-cycle, 110-volt current, actually requires only about 35 volts. The difference is wasted in useless heat from the grill or toaster.

You can avoid such troubles by building a



SMALL PAINT GUN MADE FROM ODDS AND ENDS

Popular Science Monthly, October 1936



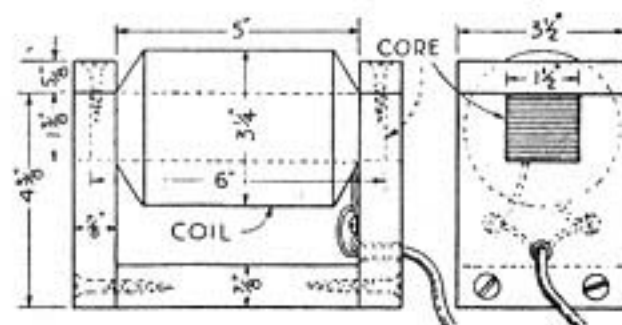
H HERE is a suggestion for making a small utility paint-spraying gun from junk. A large brass nut was cut so that there would be two sides at right angles. Two pressure grease fittings with the insides removed then were tapped in at right angles. The $\frac{1}{8}$ -in. pipe thread on them also allows for minor adjustment. The top fitting was tapped from outside for a $\frac{1}{8}$ -in. piece of pipe, which carries a pipe T on the outer end. The pipe T was plugged at one end, and a push rod inserted to operate the valve. An old tire valve was cut off and soldered inside the nipple leading to the gun.

The fitting in the jar depends on the size of the old piece of gas line tubing used.

The advantage of this gun is that it will operate on 75 or 80 lb. pressure very well, whereas a regular gun must have the pressure regulated.—P. T. POTTER.

current limiting reactance to take the place of the makeshift resistances. The reactance upsets the power factor of the line in such a way that the current flowing through the arc actually is in the neighborhood of 10 amperes although the meter runs only

Two views of the coil and a drawing that gives the dimensions of the parts. The core must be clamped down firmly



as fast as though $3\frac{1}{2}$ amperes were flowing.

The homemade reactance shown was designed especially for amateur arc furnace experiments. The core is made of transformer steel laminations or annealed iron strips measuring $1\frac{1}{2}$ by 6 in. Enough of them are used to make the core $1\frac{3}{4}$ in. thick.

After the core has been tightly wound with four or five layers of friction tape, the winding can be

started. Use No. 12 enameled, cotton covered wire. The first layer should be 5 in. long, and the end of each succeeding layer should be stepped back half the width of the wire. This gives a

cone-shaped effect and avoids the use of retaining disks. Continue winding till the outside of the coil measures $3\frac{1}{4}$ in. in diameter. Then apply several layers of friction tape to protect the winding and keep it from coming loose at the ends.

Be sure that the notches in the upright end pieces of the wooden frame are slightly less than $1\frac{3}{8}$ in. deep so that the top pieces will clamp firmly on the ends of the core.

Connections are made to the coil by drilling a hole in the upright, passing the end of a flexible cord through it, and soldering the coil end wires to the bared ends of the cord. A soldered loop should be formed in each wire so they may be



Marking initials on a tool with solution of copper sulphate crystals and salt in water

TOOL-MARKING FLUID CONTAINS NO ACID

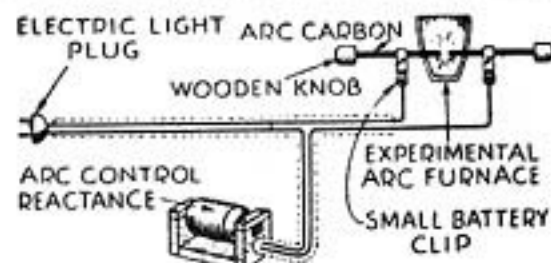
Popular Science Monthly, August 1936

The simplest tool-marking fluid that contains no acid can be made by dissolving 12 grams of copper sulphate crystals and 10 grams of salt in 40 c.c. of water, or approximately a teaspoonful of each of the chemicals in 2 oz. of water. The fluid is applied to the metal by means of a wooden stick, a pointed brush, or a sliver of quill from a feather.—R.W.

firmly clamped to the inside of the upright by means of small, roundheaded wood screws.

After the reactance is finished, give it a coat of black paint or lacquer.

A handy wiring harness for arc experiments is suggested in the diagram above. The metal or other substance to be melted can be placed in a smaller crucible suspended within the outer one. Obviously, any desired type of furnace may be built to suit the work. Bear in mind, however, that the heat is intense enough to melt iron and porcelain and must be cautiously

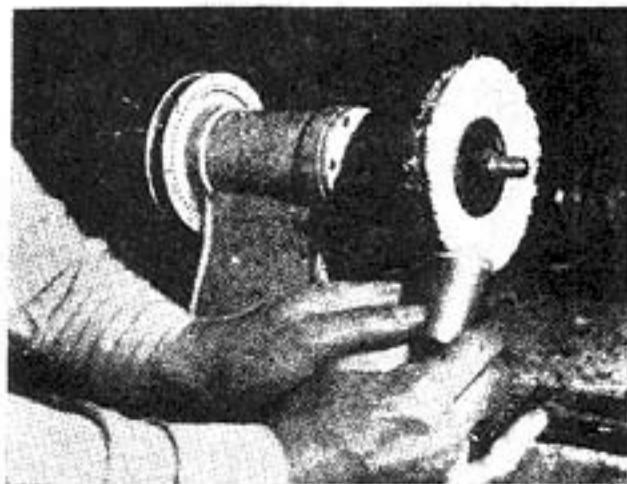


How the connections are made. No current can flow without passing through the coil

used. Do not look directly at the arc without wearing goggles.

This reactance is for use only on 60-cycle, 110-volt A. C. current. □

Mix Your Own Buffing-Wheel Compounds



Handy cardboard containers wear away to leave abrasive compound exposed to buffing wheel.

THE successful use of a buffing wheel depends to a great extent on the material that is used to charge it. A wheel of this type has in the majority of cases been associated with the polishing of metal or the strapping of an edged tool such as a chisel or plane iron but this is by no means the only use for a buffing wheel.

The polishing of small wooden surfaces may be accomplished on a buffing wheel. The material used to charge the wheel, in this case, is beeswax and pumice, and it may be

mixed in the workshop. When applied directly to the rim of the buffing wheel at high speed this compound will be useful for finishing flat wood surfaces better than can be done with either sandpaper or steel wool and for giving a high luster to metal surfaces.

Beeswax can be obtained for prices ranging both sides of 35 cents per pound. The pumice sells for from 10 to 20 cents per pound. Prepare the compound in a small jar or can placed in a pan of water. As the water is being heated drop small pieces of beeswax into the jar until half full. Stir the mixture with a piece of wire and slowly pour the pumice into the melted wax until a thick, creamy consistency is reached. Then pour into suitable containers. Cylindrical cardboard boxes which most druggists carry will cost only a penny or two and will make it unnecessary for the beeswax to be removed for use, as the cardboard wears away against the wheel.

For a full line of burnishing or abrasive compounds, you should have three grades and three buffing wheels.

Melt down wax enough to fill a box with wax and pumice, one with wax and rouge, and one with wax and fine emery dust. Buffing wheels for wood and metal should be kept separate.

You will then have the three grades of abrasive and each ideal for the purpose. If you work in both metal and wood, then by rights you should have six buffing wheels. Use of a buffing wheel with the various compounds intended for metal buffing will turn the buffer rim back and this will be transferred to wood.

A good abrasive compound for polishing wood is made of pumice and beeswax.



CHEMICALS AS AN INVESTMENT

By Kurt Saxon

CHEMICALS FOR INVESTMENT

The chemicals listed here were from two catalogues of 1968 and 1971. Few catalogues offer such a range today. The chemicals beginning with an asterisk or an X must be shipped by trucking lines or Railway Express. The others can be shipped by United Parcel Service. The seller will decide how to ship so just consider that the Xs stand for potentially dangerous and needing more careful handling.

The original prices have been left out, as they were for one ounce, four ounces and one pound. You will be ordering chemicals to use in a home business or for barter so would want to order in bulk. Also, the old prices would be irrelevant today.

Your chance to order chemicals profitably is to order in quantities from 5 to 100 or more pounds.

You should also specialize. Choose a field you are interested in, like tanning, hydroponics, agriculture, medicines, photography, food preservation, explosives, dyeing, etc., and order only the chemicals in that line. A shed full of a jumble of unrelated chemicals with no view toward a specific field, or fields, would be of little use for barter.

You might also study the Miscellaneous Chemicals section in GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY. You can then buy cheap chemicals which, when combined, will make more complex and expensive chemicals.

BIOLOGICAL STAINS INDICATORS AND SOLUTIONS

Acetone - Alcohol, for gram's process
Alcohol - Alcohol, for decolorizing
Benedict's Solution, qualitative
Bismarck Brown, 1% aqueous solution
Bismarck Brown, 2% alcoholic solution
Canada Balsam, filtered
Carbol - Fuchsin, Zeihl Neelsen
Carbol - Gentian Violet
Carmin, Borax solution
Carnoy's Fluid #1
Carnoy's Fluid #2
Cedarwood Oil, for clearing
Cedarwood Oil, for immersion
Eosine, Yellowish, 1% aqueous solution
Eosine, Yellowish, alcoholic solution
Esbach's Reagent
Fehling's Solution "A" copper
Fehling's Solution "B" alkaline
Fuchsin Acid, 2% aqueous solution
Fuchsin Basic, 1% aqueous solution
Gabbet's Stain "A"
Gabbet's Stain "B"
Gentian Violet, 1% aqueous solution
Gentian Violet, 1% alcoholic solution
Giemsa's Blood Stain, Romanowski
Grams Iodine Solution
Haematoxylin, Delafield's
Haematoxylin, Ehrlich's
Heine's Solution, qualitative
Hayem's Solution
Jenner Blood Stain
Karl Fischer Reagent
Litmus Solution, blue
Malachite Green, 1% alcoholic solution
Malachite Green, 1% aqueous solution
Methyl Blue, 1% aqueous solution
Methyl Green, 1% aqueous solution
Methyl Orange Solution (indicator)
Methylene Blue, 1% aqueous solution
Orange G, aqueous solution
Purdy's Solution
Robert's Reagent, for albumen
Safranin, 1% aqueous solution
Thionine, 1% aqueous solution
Wright's Blood Stain
Xylol, (Xylene)

STANDARD VOLUMETRIC SOLUTIONS

Acetic Acid, Normal
Acetic Acid, Tenth Normal
Hydrochloric Acid, Normal

As the world's economic situation deteriorates, more investment counselors crawl out of the woodwork. They promote stocks, high-interest savings plans, diamonds, gold and silver; not to mention paintings, antiques and various other commodities with little or no value in a situation of gut-level survival.

One popular investment counselor admitted that gold was no real assurance in the event of an economic collapse. But he said, "When things return to normal, as they will..." This is precisely the mistake made by all the investment counselors whose works I've read or have heard lecturing on TV.

Today we have the depletion of many natural resources and the increasing inaccessibility of many others, fossil fuels heading the list. There are also the rapidly changing weather patterns which make bumper crops less a certainty around the world. Then there are the increasing populations of every nation, with no sign of a turnaround, even in the U.S. (Here, fewer babies are being born but people are living longer and Wetbacks are increasing our population by millions annually).

Further, regardless of the reasons, the bulk of the upcoming working population is declining in the ability to read and otherwise function in a necessarily more complex social system. This alone, would cut down on any system's chances of coming out of the kind of depression our economic forecasters predict. So things will not return to normal in our lifetimes.

Civilizations, not simply economic systems, will collapse, totally and permanently. What the children of the survivors do with the diamonds, gold, etc., will not justify your present investments. Also, if the bulk of your investments are in the form of "precious" metals, etc., your children may not survive at all.

Diamonds, precious metals, artworks and such, depend for their value on an upper class with such a surplus of the necessities that they must put part of their wealth in compact nonessentials. Otherwise they'd have to have warehouses in which to store their surpluses.

Banks, as we know them, are a relatively recent addition to civilized economies. They will not return until civilization rises again to the point where valuables can be converted into currency, to be loaned out at interest.

For at least a generation or two after the crash, barter will be the only legitimate means of exchange. There may be village stores where the owner takes in whatever the customer has and trades him from his stock or its value in something another trader has left for barter.

In this way, a man might set up a kind of clearing house where people can leave goods and take what they need from among items left by others of the same general value. Of course, the owner of the clearing house would do the bargaining, making sure he got his share, which would be the difference in value between one item and another.

For instance, a dozen eggs might be traded for a second-hand shirt. The owner of the clearing house would then keep two eggs and trade ten of them for a quart of homemade wine. Then he would trade the wine by the glassful for odds and ends drinkers would hand over in exchange.

In this way, and in individual cases of barter, only items of practical value and immediate use would be exchanged. The only way you could get anything you needed would be to give another, something he needed, be it salvaged belongings or something you've made or grown.

What if you took into such a clearing house a diamond for which you had paid \$1000.00 as an "investment"? Since only things of value would be traded for, what could you get for your diamond? Maybe a pound of salt, if the trader was generous. For your diamond would be of no use to anyone, except as an ornament, and a pound of salt or a chicken or a pair of second-hand shoes would be a good return, indeed.

The same would apply if you tried to trade the diamond to any farmer or craftsman. A farmer might give you a bushel of tomatoes for it, if he had a son about to marry and knew a craftsman who could make a ring for it.

Hydrochloric Acid, Tenth Normal
 Iodine, Tenth Normal (N/10)
 Nitric Acid, Normal
 Nitric Acid, Tenth Normal
 Potassium Hydroxide, Normal
 Potassium Hydroxide, Tenth Normal
 Silver Nitrate, tenth normal
 Sodium Hydroxide, Normal
 Sodium Hydroxide, Tenth Normal
 Sulfuric Acid, Normal
 Sulfuric Acid, Tenth Normal

DRY ANILINE COLORS

Soluble in alcohol or water. Suitable for technical work and making microscopic stains.

Auramine O (Yellow)
 Bismarck Brown
 Congo Red
 Fluorescein (Uranine)
 Fuchsin Basic (Red)
 Malachite Green
 Methyl Orange
 Methyl Violet
 Methylene Blue
 Nigrosine (Black)
 Primuline (Yellow)
 Rhodamine B
 Safranin (Red)

- Acetamide, crystals, pure
- Acetanilide, powder, USP
- * Acetone, USP-CP
- Acid, Acetic, USP (dil. 5.0%)
- * Acid, Acetic, conc. 80% pure
- * Acid, Acetic, Glacial, 99.5%
- Acid, Acetylsalicylic, USP
- Acid, Adipic, purified
- Acid, Benzoic, crystals, USP
- Acid, Boric, powder, pure
- * Acid, Chromic, gran. pure
- Acid, Citric, USP
- Acid, Gallic, powder, NF-VII
- * Acid, Hydrochloric, (conc.)
- Acid, Hydrochloric, (dil. 5.0%)
- * Acid, Lactic, purified
- Acid, Lactic, (dil. 5.0%)
- Acid, Molybdic, CP-85%
- * Acid, Nitric, (conc.)
- Acid, Nitric, (dil. 5.0%)
- Acid, Oleic, purified
- * Acid, Oxalic, crystals, pure
- Acid, Palmitic, purified
- * Acid, Phosphoric, (conc.)
- Acid, Phosphoric, (dil. 5.0%)
- Acid, Phthalic, Anhydride
- * Acid, Pyrogallol, crystals, pure
- Acid, Salicylic, USP, crystals
- Acid, Silicic, powder, pure
- Acid, Stearic, USP
- * Acid, Sulfuric, (conc.)
- Acid, Sulfuric, (dil. 5.0%)
- Acid, Tannic, powder
- Acid, Tartaric, USP, powder
- Agar Agar, USP, powder
- * Alcohol, Amyl, purified, iso
- * Alcohol, Butyl, pure, normal
- * Alcohol, Ethyl, (burner fluid, den.)
- * Alcohol, Isopropyl, pure
- * Alcohol, Methyl, (wood alc.)
- Alizarine, 20% solution
- Alpha Naphthol, pure
- Aluminum Acetate, powder, purified
- Aluminum Ammonium Sulfate, NP, cryst
- Aluminum Chloride, USP, cryst.
- Aluminum Hydroxide, powder
- Aluminum Metal, turnings
- * Aluminum Metal, powdered
- Aluminum Metal, foil, strips
- Aluminum Nitrate, crystals, pure
- Aluminum Oxide, powder, pure
- Aluminum Potassium Sulfate, cryst.
- Aluminum Sodium Sulfate, pure
- Aluminum Sulfate, gran. pure
- Alundum, 60 mesh
- 3-Aminophthalhydrazide (Luminol)
- Ammonium Acetate, crystals, CP
- Ammonium Biborate, purified
- * Ammonium Bichromate (Dichromate)

Truely, a person who invests \$100.00 in packets of needles and spools of thread will be in a better position to barter with anyone than the one with a million dollars worth of diamonds, today. Besides, while you might scrimp and deny yourself useful barter goods to buy diamonds, any street lout could outdo you by simply looting the nearest jewelry store.

Then take gold. Gold might be recognized as a medium of exchange in your lifetime. But certainly not for some time after the crash. It might not be exchangeable for years. You can't eat it and it will be some time before it will have any practical application in industry. It can be melted for jewelry, but for quite awhile, its present value will make it a poor exchange for necessities. For instance, you might trade a Krugrand for a chicken. But that wouldn't please you and the former owner of the chicken would have to put it by for later. Even so, he might rather trade the chicken for something he needed right away.

If you had a two-ounce bar of gold, you'd be in even worse shape. The austerities of all those about you would cause you to take a terrible loss on it in any trade; again, if you could trade it at all. I wouldn't give you anything for it unless I intended to melt it for enamel glazes or suchlike.

The same goes for silver. It would return as a medium of exchange sooner than gold, but not until it was established as having an agreed upon value by everyone. In the meantime, you'd probably get rid of your whole stock just for the bare necessities.

Even worse than being caught with a stock of nothing but diamonds and/or gold, would be to be the victim of the many ripoff artists following the investment craze. Reports are increasing of "diamond" merchants bilking suckers of \$ thousands with phoney stones or those of far less quality than they pay for. Unless you are an expert, you could well wind up with a \$3000.00 Zircon to trade for a chicken later on.

If gold is your thing, you might wind up with lead bars coated with a thin layer of solid gold. Pages 9 and 36 of THE SURVIVOR tell how to make artificial gold and silver any crazed layman would pay Federal Reserve notes for. Not to worry, though. You could probably turn right around and trade it all to some sucker for an old jacket five years from now.

Even with genuine valuables, incidents in our century have proven that visible wealth is no guarantee of survival. After the Bolsheviks took over Russia, priceless works of art, golden ikons, diamond and silver broaches, etc., were exchanged for meals. The Russian aristocracy which was not slaughtered immediately, was reduced to beggary within weeks. The Chinese upper classes converted all their wealth into gold before Mao Tse Tung took over. They were wise since they meant to flee to where gold had value. Those who didn't make it out were shot if gold was found on them.

Unless you are of modest means and intend to invest your surpluses in simple barter goods, chemicals are your best guarantee of solvency after the crash. Chemicals can be cheap or very expensive. Therefore, regardless of your situation, chemicals of one kind or another are an excellent hedge against future shortages. I can think of few survival trades, except simple craftworks, which will not require chemicals, unavailable from dependable sources when civilization goes its inevitable way.

For medicines alone, chemicals will command the highest barter prices. Pharmacies will be among the first business to be looted and their less attractive contents destroyed. Even old-fashioned medicines described in my own MEDICINES LIKE GRADDAD USED TO MAKE, especially with its MEDICAL STUDENT'S MANUAL OF CHEMISTRY, 1889, will enable anyone to combine relatively simple chemicals into greatly demanded medications. Ether and chloroform, bought now or made from instructions in this book will command any price from those needing surgery or dental work.

Chemicals as meat preservers, tanning elements, for shoe polish, inks, dyes, etc., will be unavailable except from those who buy them soon. GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY, with its dictionary of old-fashioned chemical terms and instructions for making more complex chemicals, will give any chemical buyer the information he needs to interpret and use

- * Ammonium Bisulfate, crystals, pure
- * Ammonium Bromide, gran. NF
- * Ammonium Carbonate, USP, powder
- * Ammonium Chloride, gran. pure
- * Ammonium Citrate, di, USP
- * Ammonium Hydroxide, pure, sol.
- * Ammonium Molybdate, CP solution
- * Ammonium Nitrate, gran. pure
- * Ammonium Oxalate, crystals, pure
- * Ammonium Perchlorate, crystals, pure
- * Ammonium Persulfate, crystals
- * Ammonium Phosphate, mono, pure
- * Ammonium Phosphate, di, purified
- * Ammonium Stearate, paste
- * Ammonium Sulfamate, crystals, pure
- * Ammonium Sulfate, crystals
- * Ammonium Thiocyanate, pure
- * Amyl Acetate, purified
- * Aniline, purified
- * Antimony Chloride, tri. pure
- * Antimony Metal, lumps
- * Antimony Metal, powder, pure
- * Antimony Oxide, tri.
- * Antimony Potassium Tartrate, USP
- * Antimony Trioxide, powder
- * Antimony Sulfide, Tri, black powder
- * Antimony Sulfide, penta, red powder
- * Arsenic Metal, lump, pure
- * Arsenic Sulfide, red powder
- * Asbestos, short fiber
- * Asphaltum, gum, powder
- * Asphaltum Varnish
- * Balsam, Canada, filtered
- * Barium Carbonate, powder
- * Barium Chlorate, powder, pure
- * Barium Chloride, crystals, pure
- * Barium Hydroxide, crystals
- * Barium Nitrate, powder, pure
- * Barium Peroxide, (dioxide) powder
- * Barium Sulfate, USP, powder
- * Barium Sulfide, powder, pure
- * Bentonite, powder
- * Bees Wax, yellow
- * Benedict's Solution
- * Benzene, (benzol) pure
- * Beta Naphthol, crystals, pure
- * Bismuth Chloride, pure
- * Bismuth Metal, lumps CP
- * Bismuth Nitrate, sub. USP
- * Borax Glass, powder
- * Butyl Acetate, purified
- * Cadmium Carbonate, powder, C.P.
- * Cadmium Chloride, cryst. lab grade
- * Cadmium Nitrate, cryst. lab grade
- * Cadmium Metal, mossy
- * Calcium Acetate, powder, lab grade
- * Calcium Carbide, granular
- * Calcium Carbonate, powder
- * Calcium Citrate, powder
- * Calcium Chloride, granular
- * Calcium Cyanamide, granular
- * Calcium Fluoride, powder
- * Calcium Hydroxide, powder, lab grade
- * Calcium Hypochlorite, powder
- * Calcium Lactate, powder, lab grade
- * Calcium Metal, turnings
- * Calcium Nitrate, crystals, pure
- * Calcium Oxide, powder
- * Calcium Phosphate, mono, powder
- * Calcium Phosphate, di, pure
- * Calcium Phosphate, tri, powder
- * Calcium Sulfate, powder
- * Calcium Sulfide, powder, lab grade
- * Carbon Disulfide, purified
- * Carbon Tetrachloride, pure
- * Carborundum, granular
- * Cellosolve Acetate, pure
- * Ceresine Wax, light
- * Charcoal, Wood, powder
- * Charcoal, Wood, lumps
- * Chloroform, N.F. pure
- * Chromium Chloride, CP crystals
- * Chromium Chloride, 5% solution
- * Chromium Metal, CP lumps

the old formularies. The old formularies in the Atlan line and elsewhere will give the investor in chemicals his best ideas on what will be in most demand in a simpler culture.

Investing in a store of chemicals will be a far better shot at a safe future than anything you can get in the way of "precious" stones or metals. Moreover, chemicals will be far less attractive to possible looters, as their bulk will be a burden. Also, in the event of a warlord who might requisition valuables, your chemicals would be left to you. This is because, as the stocker, you would be in the best position to apply them to their ultimate benefit to the community, and consequently could demand whatever the traffic would bear.

Elsewhere in this issue is a list of chemicals taken from a 1971 catalogue mailed to students and hobbyists. Some of them are common and can be purchased locally from supermarkets, garden supply stores and even at your local pharmacy. However, most such common chemicals are not sold in bulk locally. Aside from sulphur and charcoal in briquette form, most chemicals you will buy in bulk must be ordered.

If your pharmacist will cooperate, he can order chemicals in bulk. However, most pharmacists won't concern themselves with supplying chemicals to laymen.

Chemical manufacturers are also seldom interested in selling their chemicals to individuals, preferring to sell through salesmen, who in turn, sell to pharmacies, labs, etc. Of course, if you order by the ton, I'm sure the manufacturers would give you more attention. Your pharmacist can put you in touch with a salesman working for a chemical company.

Such salesmen still are not your best bet. They usually represent pharmaceutical houses and manufacturers of labware. A salesman may not have contacts with companies selling bulk chemicals, since pharmacies usually only buy small amounts such as four ounce jars of potassium nitrate, eight ounce bottles of glycerine, etc. Otherwise, the salesman to pharmacies mainly deals in prescription drugs and non-prescription medications.

Chemical manufacturers are not the best contacts for buying general chemicals. They usually sell by the train car load and would not be interested in your relatively small purchases. Also, they might manufacture only a limited variety of chemicals geared to a specific field, such as agriculture, cleaning agents, etc.

Other chemical manufacturers which make or buy chemicals for laboratories, deal only through salesmen who, in turn, sell only to medical and school laboratories and will not sell to individuals, although they will often sell to companies dealing with hobbyists with home labs.

Magazines such as POPULAR SCIENCE and POPULAR MECHANICS carry classified ads for mailorder chemicals. However, they sell such tiny quantities that they are not to be considered for bulk orders. Also, they are not reliable, as they go out of business, usually by the time you send for their catalogues. Part of the reason for this is that they are increasingly limiting their chemicals to the most harmless, used by children with toy chemical sets.

Years ago, such mailorder chemical companies flourished because they sold a wide range, including chemicals used in fireworks. Then when fireworks were universally banned, they became paranoid and removed everything which could be used for any potentially destructive purpose. Such chemicals have many other uses but mass paranoia about bombers has just about wiped out the mailorder chemicals businesses.

All this is not to discourage you from trying all the above sources. After all, people who have something to sell want buyers. If you can pay and are not an obvious threat to their business license they want your trade. Their only fixed requirements are that you order enough to make the transaction worth their efforts and that you identify yourself as an adult. This is to protect them against lawsuits from parents of injured children.

In California's Bay area, drop around to ZERO WASTE Systems, Inc., 2928 Poplar St., Oakland, CA 94608 (415) 893-8257. They stock the overproduction of chemical factories and surplus or sellout supplies from various chemical

Chromium Nitrate, reagent
 Chromium Oxide, green powder, CP
 Chromium Potassium Sulfate, cryst
 Chromium Sulfate, 5% solution
 Cobalt Acetate, lab grade
 Cobalt Chloride, crystals, pure
 Cobalt Chloride, 5% solution
 Cobalt Metal, pure, lumps
 Cobalt Nitrate, CP crystals
 Cobalt Oxide, black, powder
 Cobalt Sulfate, cryst. lab grade
 Cochineal, powder
 Congo Red, solution
 * Copper Acetate, crystals, pure
 * Copper Acetoarsenite, powder
 * Copper Ammonium Sulfate, pure
 * Copper Bromide, (ic) pure
 * Copper Carbonate, powder (ic)
 * Copper Chloride, (ic) pure
 Copper Metal, pure
 Copper Oxide, (ic) black powder
 * Copper Nitrate, (ic) crystals
 * Copper Sulfate, crystals, pure
 Copper Sulfide, (ic) powder
 Corn Starch, powder, USP
 * Cyclohexanol, purified
 Dextrine, yellow powder
 Dextrose, USP powder
 Diatomaceous Earth, powder
 Dimethylglyoxime, CP solution
 Dimethylglyoxime, CP powder
 Diphenylamine, crystals
 * Ether, pure (for solvent use)
 * Ethyl Acetate, lab grade
 * Ethylene Dichloride, pure
 Fehling's Solution "A" copper
 Fehling's Solution "B" alkaline
 Fuller's Earth, powder
 * Formaldehyde, USP solution
 Gelatine, USP granular
 Glass Wool, fine, lead free
 Glycerine, USP, white
 Glyoxal, solution, lab grade
 Graphite, lumps
 Graphite, powder
 * Guanidine, Nitrate, powder
 Gum Arabic, powder, USP
 Gum Asphaltum, powder
 Gum Ester, lumps, pure
 Gum Olibanum, lumps (frankincense)
 Gum Shellac, orange, flakes
 Gum Shellac, white, gran. powd.
 Heptaldehyde, pure
 Hexachlorethane, crystals, pure
 Hexachlorobenzene, powder
 Hexamethylene Tetramine, USP
 * Hydrogen Peroxide, USP solution
 Hydroquinone, crystals, pract.
 Infusorial Earth, powder
 * Iodine, crystals, USP
 Iodine, solution
 Iron Ammonium Citrate, (ic) USP
 Iron Ammonium Sulfate, (ferrous) pure
 Iron Ammonium Sulfate, (ic) crystal
 Iron Chloride, (ferrio) lumps
 Iron Metal, filings
 Iron Metal, powder
 Iron Oxide, (ferrio) red, powder
 Iron Oxide, black powder
 Iron Sulfate, (ferrous) gran
 Iron Sulfide, (ferrous) granular
 * Isopropyl Acetate, pure
 Kaolin, NF powder
 * Kerosine, purified
 Lactose, USP powder
 Lamp Black, powder
 Lanolin, USP, pure
 * Lead Acetate, crystals, pure
 * Lead Carbonate, powder, pure
 Lead Metal, foil, pure
 Lead Metal, lumps
 Lead Metal, shot
 * Lead Nitrate, crystals, lab grade
 * Lead Oxide, mono, litharge
 * Lead Oxide, di, brown powder

businesses. They have nearly everything and you can just go and get it. They don't ship except on huge orders. Call if you're uncertain.

Ordering the chemicals in bulk brings the price down considerably. You can figure that an order of 100 pounds would make each pound in a 100 pound order 1/4 the price of a single pound. Reselling these chemicals to craftsmen and home manufacturers after the crash would bring astronomical profits. You could also begin selling them to friends now, or bury them until needed.



* Lead Oxide, tetra (red)
 * Lead Tartrate, crystals, pure
 Lead Sulfide, lumps, galena
 Lime Water, test solution
 Lithium Carbonate, CP powder
 Lithium Chloride, CP crystals
 * Lithium Fluoride, CP powder
 * Lithium Nitrate, crystals, pure
 Litmus, granular powder
 Litmus, test solution
 Magnesium Carbonate, powder
 Magnesium Chloride, crystals
 * Magnesium Metal, fine powder
 * Magnesium Metal, ribbon
 * Magnesium Metal, turnings
 Magnesium Nitrate, crystals, pure
 Magnesium Oxide, powder, pure
 Magnesium Sulfate, USP crystals
 Manganese Chloride, purified
 Manganese Dioxide, black powder
 Manganese Metal, lumps, CP
 Manganese Sulfate, powder, pure
 Marble Chips, (for CO2)
 * Mercury Chloride, (ic) U.S.P.
 * Mercury Iodide, (ous) pure
 * Mercury Metal, distilled
 * Mercury Oxide, (ic) U.S.P.
 Methyl Orange, (test solution)
 Methyl Salicylate, pure
 Naphthalene, flakes, pure
 Naphthol, Alpha, pure
 Naphthol, Beta, pure
 Nichrome Wire
 Nickel Ammonium Sulfate, 5% solution
 Nickel Ammonium Sulfate, crystals
 Nickel Chloride, cryst. lab grade
 Nickel Metal, pure
 Nickel Nitrate, crystals
 Nickel Sulfate, purified
 * Oil, Aniline, purified
 Oil, Cedarwood, for clearing
 Oil, Cedarwood, for immersion
 Oil, Corn, edible
 Oil, Cottonseed, purified
 Oil, Olive, edible
 Oil, Pine, distilled
 Oil, Paraffin, white USP
 Oil, Peanut, edible
 * Oil, turpentine, light
 Paraffin Oil, white
 * Pentamethylenedione, purified
 * Petroleum Ether, (ligroin)
 Phenol Para Tertiary Amyl
 Phenolphthalein, powder, U.S.P.
 Phenolphthalein, test solution
 * Phosphorus, red powder
 Platinum Wire, 30 gage
 Potassium Acetate, crystals
 * Potassium Bichromate (di) crystals
 * Potassium Bisulfate, crystals
 Potassium Bitartrate, NF powder
 Potassium Bromide, USP crystals
 Potassium Carbonate, gran.
 * Potassium Chlorate, purified
 Potassium Chloride, crystals, pure
 * Potassium Chromate, crystals
 * Potassium Ferriocyanide, photo
 * Potassium Ferrocyanide, crystals

* Potassium Hydroxide, flakes
 Potassium Hydroxide, 5% solution
 Potassium Iodate, CP crystals
 Potassium Iodide, USP crystals
 * Potassium Nitrate, pure
 * Potassium Oxalate, purified
 * Potassium Perchlorate, powder
 * Potassium Permanganate, USP crystals
 Potassium Permanganate, solution
 * Potassium Persulfate, crystal
 * Potassium Pyrosulfate, C.P.
 Potassium Sodium Tartrate, NF, pwd.
 Potassium Sulfate, crystals
 Potassium Sulfide, lumps
 Potassium Thiocyanate, purified
 Potassium Phosphate, mono, pure
 Propylene Glycol, pure
 Pumice, lumps
 Pumice, powder, NF
 Rose's Metal, alloy
 Rosin, yellow lumps
 Rosin, yellow powder
 * Selenium Metal, purified
 Shellac, orange gum
 Shellac, white gum
 Silica, fine powder
 Silicon Metal, lumps
 Silver Metal, lumps
 * Silver Nitrate, crystal, U.S.P.
 Soda Lime, granular
 Sodium Acetate, crystal, N.F.
 Sodium Acetate, crystal, C.P.
 Sodium Ammonium Phosphate, CP
 Sodium Benzoate, USP, crystals
 Sodium Bicarbonate, USP powder
 * Sodium Bichromate, (di) crystals
 * Sodium Bisulfate, granular
 Sodium Bisulfite, meta, powder
 Sodium Borate, tetra, gran.
 Sodium Bromide, USP crystals
 Sodium Carbonate, powder
 Sodium Carbonate, sesqui
 * Sodium Chlorate, pure
 Sodium Chloride, crystals, lab grade
 * Sodium Chromate, purified
 Sodium Citrate, USP crystals
 Sodium Ferrocyanide, crystals, pure
 * Sodium Fluoride, powder
 Sodium Hypochlorite, 5% solution
 * Sodium Hydroxide, flakes
 Sodium Hydroxide, 5% solution
 Sodium Iodide, USP crystals
 * Sodium Metal, lump, pure
 * Sodium Nitrate, granular, pure
 * Sodium Nitrite, USP crystals
 * Sodium Oxalate, powder
 * Sodium Peroxide, gran. pure
 Sodium Phosphate, mono, pure
 Sodium Phosphate, dibasic
 Sodium Phosphate, tri, granular
 Sodium Perborate, USP, powder
 Sodium Salicylate, USP, crystals
 Sodium Silicate, solution
 Sodium Silicate, ortho, powder
 Sodium Sulfate, powder, pure
 * Sodium Sulfide, flakes
 Sodium Sulfite, powder
 Sodium Thiosulfate, photo, crystals
 Sodium Tripoly Phosphate, pure
 Sodium Tungstate, C.P.

Steel Wool, fine grade
Spermaceti Wax, USP lumps
Strontium Carbonate, powder
Strontium Chloride, crystals
* Strontium Nitrate, pure
Sulfur, powder, pure
Sulfur, lumps (brimstone)

Talc, powder, pure
Tar Oil, coal,
* Tellurium Metal, pure
* Thermit, (for welding)
* Thermit, Igniting Mixture
Tin Chloride, (stannous) crystals
Tin Oxide, white powder, pure
Tin Metal, foil, pure
Tin Metal, mossy, lumps

* Toluene, (toluol)
Tungsten Metal, powder, pure
Turkey Red Oil, pure
Turnerio (ouroumin) powder
Turnerio, test solution
Urea crystals, purified
Wax, Ceresine, white
Wax, Carnauba, pure
Wax, Paraffin, purified
Wax, Spermaceti, U.S.P.
Wood's Metal, alloy

* Xylene, (xylol) pure

Zinc Acetate, crystals, pure

Zinc Carbonate, powder, pure
* Zinc Chloride, gran, pure
Zinc Chloride, lumps
Zinc Chloride, 5% solution
Zinc Metal, mossy, lumps
* Zinc Metal, powder, (dust)
Zinc Metal, sticks
Zinc Nitrate, crystals
Zinc Oxide, USP powder
Zinc Sulfate, lab grade
Zinc Sulfide, powder, pure



LABORATORY SAFETY

By Kevin Christopher

Chemistry is a little like cooking. The good chemist, like the good cook, can improve upon a recipe; the beginner had better not experiment too much. However, the similarity ends here; rarely does one read of a cheese souffle exploding in someone's face.

Every year, literally thousands of home experimenters, mostly kids, are killed or maimed while experimenting. These accidents can be avoided if a few simple safety rules are followed.

Yes, this is the part where I bitch to you about safety, but don't put this down and go read something else. It's important. After the crash, some of you will need a lab to prepare medicine, weapons or whatever and this is an essential part. I've dabbled in kitchen chemistry for years and have had oh, so many accidents. But, I've never been seriously hurt. I've been burned a few times and have ruined a number of shirts, but I'm still happy, healthy and in one piece. So, pay attention.

The first thing you're going to need is a suitable place to work. This can be the most difficult part. It should be someplace such that no one will mind when you fill it up with hydrogen sulphide or some other distasteful and easily produced gas. A separate building would be excellent if you can swing it. Outside or in your garage, if you have one, would also be good. For myself, I have an old picnic table with a Hibachi on it. On nice days, I do my work outside with the table downwind. If the creative urge hits me on a rainy day, I move the table into the garage and put a fan behind me to blow away the fumes. This arrangement serves me well and has done so for many years.

By the way, don't think that a lab has to be a great, big room with exhaust fans and shelves and stuff. My first lab was a converted toy box.

One of the most important aspects to check into when choosing your location is ventilation. Chemical fumes are often

highly noxious and can be poisonous even in small amounts. Ideally, your ventilation arrangement should provide for air to move across your lab set-up and out an open window or something. So, either work outside with your experiment downwind or arrange for some kind of ventilation to blow the fumes away from you. And never, ever even think of setting up a lab in a windowless room! This is also

why you should try not to work alone. It's real nice to have a friend around to drag you away and give you mouth-to-mouth after you've just gotten a whiff of something.

The next thing you need is some kind of eye protection. Being blind is no fun at all and I surely would be if I didn't wear glasses. For those of you who also wear glasses, you have enough protection although you might want to get some heavy, clear plastic and fix up a couple of eye protectors for side splashes (see illustration). For those of you who don't

SAFETY IN THE LABORATORY INCOMPATIBLE MATERIALS

Certain combinations of chemicals are remarkably explosive, poisonous or hazardous in some other way, and these are generally avoided as a matter of course. There are many others that are perhaps equally dangerous but do not come to mind as readily. The following list, although not complete, may serve as a memory-refresher. Stop and think for a moment before starting any work, especially if one hazardous chemical is involved.

DO NOT CONTACT

Alkali metals, such as calcium, potassium and sodium with water, carbon dioxide, carbon tetrachloride, and other chlorinated hydrocarbons.

Acetic Acid with chromic acid, nitric acid, hydroxyl-containing compounds, ethylene glycol, perchloric acid, peroxides and permanganates.

Acetone with concentrated sulphuric and nitric acid mixtures.

Acetylene with copper (tubing), fluorine, bromine, chlorine, iodine, silver, mercury or their compounds.

Ammonia, Anhydrous with mercury, halogens, calcium hypochlorite or hydrogen fluoride.

Ammonium Nitrate with acids, metal powders, flammable fluids, chlorates, nitrates, sulphur and finely divided organics or other combustibles.

Aniline with nitric acid, hydrogen peroxide or other strong oxidizing agents.

Bromine with ammonia, acetylene, butadiene, butane, hydrogen, sodium carbide, turpentine, or finely divided metals.

Chlorates with ammonium salts, acids, metal powders, sulfur, carbon, finely divided organics or other combustibles.

Chromic Acid with acetic acid, naphthalene, camphor, alcohol, glycerine, turpentine and other flammable liquids.

Chlorine with ammonia, acetylene, butadiene, benzene and other petroleum fractions, hydrogen, sodium carbides, turpentine and finely divided powdered metals.

Cyanides with acids.

Hydrogen Peroxide with copper, chromium, iron, most metals or their respective salts, flammable fluids and other combustible materials, aniline and nitro-methane.

Hydrogen Sulfide with nitric acid, oxidizing gases.

Hydrocarbons, generally, with fluorine, chlorine, bromine, chromic acid or sodium peroxide.

Iodine with acetylene or ammonia.

Mercury with acetylene, fulminic acid.

Nitric Acid with acetic, chromic and hydrocyanic acids, aniline, carbon, hydrogen sulfide, flammable fluids or gases and substances which are readily nitrated.

Oxygen with oils, grease, hydrogen, flammable liquids, solids and gases.

Oxalic Acid with silver or mercury.

Perchloric Acid with acetic anhydride, bismuth and its alloys, alcohol, paper, wood and other organic materials.

Phosphorous Pentoxide with water.

Potassium Permanganate with glycerine, ethylene glycol, benzaldehyde, sulfuric acid.

Sodium Peroxide with any oxidizable substances, for instance: methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerine, ethylene glycol, ethyl acetate, furfural, etc.

Sulfuric Acid with chlorates, perchlorates, permanganates and water.

wear glasses, get a pair of goggles or something.

Another thing: follow directions. I know that sounds really stupid, but some people are so pig-headed and so simple-minded that they just have to do things their own way. Don't be one of those people. You'll get hurt. However, that's not to say "don't experiment." Do experiment, but when you do, use only very small amounts of chemicals to start with. Then, if nothing goes wrong, try a little bit more next time.

And always have some kind of fire protection around. This can be anything from a hose or blanket to a fire extinguisher but have something you can depend on.

Fire is an excellent reason for having your lab away from everything. If a fire gets out of hand, all it can destroy is your working surface. My picnic table has several good-sized holes in it from reactions that got out of hand. They did little other damage because I have a hose handy. But don't be overly brave either. If a fire is raging out of control, don't stay and fight it—run like bloody hell.

Now, on to the chemicals themselves. Don't be afraid of chemicals; just have a good, healthy respect for them. They contain powers beyond belief. The only problem is that they don't care who they release their powers on so be good to them.

An extremely useful little chart which will aid you in being good to your chemicals is called "Safety in the Laboratory: Incompatible Materials." It is free and can be ordered from Science Products Division; Mallinckrodt Chemical Works; P.O. Box 5439; St. Louis, Missouri 63160. (See Page 398.)

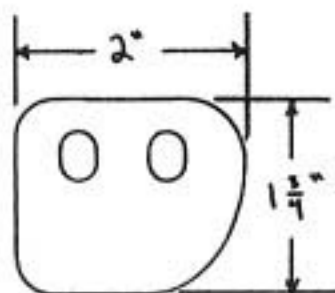
This is a small wall chart which lists most of the chemicals which do bad things when you mix them. While you're ordering it, you might as well send 50c for Mallinckrodt's chemical catalog.

If, for some reason, you have to put a chemical bottle in storage, even for a short time, label it. It doesn't take a particularly forgetful person to be confused about which of two identical bottles contain a certain chemical. Even if you're storing an unknown, label it as such. It's not that much trouble and will save you a lot of grief in the long run. And, if you were stupid (that's right—stupid) enough to keep something in an unlabelled container and find it again, throw it out even if you're absolutely, 100% sure of what the chemical is. If, by some freak chance, you're wrong, it could mean your life.

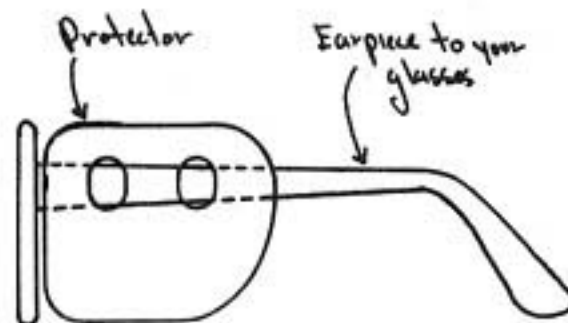
By the way, when storing chemicals, make sure that the chemical doesn't react with either container or its lid.

And don't store explosives! As a general

Material: Clear, heavy plastic
Make Two



Side Splash Protector



How to use them.

rule, I don't like bombs or explosives. If you must make an explosive, make it, blow it up and be done with it. Explosive compounds, especially homemade ones, get awfully touchy when they're stored and there are very specific rules for storing them which are different for each explosive. So, it's much easier to just forget about them.

Keep your lab and chemicals locked up. There are two reasons for this: First, it keeps anyone from getting at your stuff and using it against you and second, it protects people from themselves. If you put your average citizen in a fully-stocked chem lab with all of those neat flasks and chemicals and stuff, he's going to think that he's Joe Chemist and try to mix something up. The next thing you know, you'll be scraping him off the wall with a putty knife.

No discussion of chemical safety would really be complete without a mention of waste disposal. Just what does one do with all of that icky stuff left over in one's flask? Accumulated wastes can lead to fire, irritating fumes, damage to equipment and just generally bad things.

Solid wastes should be wrapped in newspaper and put in an incinerator or covered trash can. Liquid chemical wastes can usually be washed down your kitchen sink if it doesn't have a garbage disposal unit. Run lots of cold water down the drain after using it. Strong acids have to be neutralized before they can safely go down your drain. Simply throw some marble chips, clam shells or oyster shells into the container with the acid and wait until all the bubbling stops. Some types of gravel can be used in place of the marble chips, etc. Anyway, the acid is now safe to wash down your drain.

Flammable liquids are another story. They should never be run down a drain as many liquids of this type don't mix with water and are so light that they collect at the top of the sink trap instead of being washed away. Instead, pour flammable liquids onto open, ungrassed ground far

away from any tree or building. Don't dispose of them by burning.

Actually, all chemical wastes can be disposed of in this way, but it is a good deal less convenient than the other ways. Nothing will grow on your chemical disposal area, so don't use your front yard.

Broken glass (and there will be broken glass, take my word for it) should be immediately swept up and thrown away. Small slivers of glass can be easily picked up with a wet paper towel.

One thing though—when you get rid of cyanide wastes or anything that even involved the use of a cyanide, make absolutely certain that they don't mix with any acid, even vinegar, otherwise prussic acid will be formed and we don't want that, do we?

Plants and such from which you've just extracted something can be disposed of with your household food wastes.

When doing an experiment, there are also a few rules that need to be followed:

Always work with a purpose. More accidents are caused by just messing around than from any other cause. If you're going to make something, make it and close up shop.

Don't leave your lab while something is going on. Even if you just have one lousy alcohol burner going, you should stay and watch it. Bring in a book, television or something to keep you occupied, but try to be there. I know that it's a pain, but would you rather have your lab burn down?

This brings up a very important point about heating flammable chemicals. Some solvents such as ether and carbon disulphide can catch fire if you just look at them cross-eyed, so never heat any flammable chemical over an open flame or a hot plate with exposed filaments. Instead, use an insulated hot plate, a hot water bath or a hot oil bath.

Don't carry a lit alcohol burner around either. If you should drop it and it breaks, the effect will be exactly the same as if someone dropped a Molotov cocktail at your feet.

In general, before doing an experiment you should take a few minutes to think through what you're about to do. Think about each stage of the experiment and what you're supposed to do at each step. Think about the reacting chemicals in terms of flammability, toxicity and reactivity (how reactive the chemical is). Then, do the same thing with the product chemicals. Think about how violent the reaction will be and what you should do if it gets out of hand. Are the chemicals heat, light or impact sensitive? What should you do if you get a dose of

whatever you have in your flask? What should you do if your cooling system or the water supply fails? What will happen if air or water gets into your equipment? Is the ventilation adequate? In short, think.

The "Incompatible Materials" chart will help for this. Another fine book is called **THE CONDENSED CHEMICAL DICTIONARY** edited by Gessner G. Hawley. It costs upwards of \$40 so I don't think you'll want to rush right out and buy one but most public libraries have it. The book lists most of the common chemicals, their properties, hazards involved, vague

derivations and the like.

If you really want to get into kitchen chemistry, a good way to start is by ordering **GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY**.

In summary, these are just general rules for a very specific subject and I don't expect you to remember them all, but try to pick up the general principles. They all amount to little more than common sense and a bit of knowledge. Basically, if you think, be careful and try not to take chances, you should be all right.

SENSITIVE BALANCE BUILT FROM SCRAPS

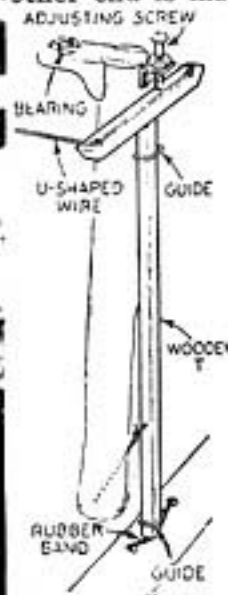
By DALE W. ANSELL

Popular Science 1937



commonly called, the sensitivity. 2. All three knife edges must be in the same plane. 3. The longer the power arms, the greater the sensitivity and the longer the period of oscillation; however, the beam must be rigid. 4. The lighter the beam, the greater the sensitivity.

A section of razor blade is set securely in a slot in the beam, perpendicular to the plane of the beam. The indicator is iron wire, flattened and pointed at one end. The other end is inserted in the beam.



How oscillation arrester is held on the column

On top of the beam, fasten a metal bracket to hold the adjustment screw. Inlay iron plates in extreme ends of beam and file a nick in each to locate the knife edges. Nicks must be same distance from central knife edge and perpendicular to plane of beam.

A scale of ten divisions, each being 12 millimeters, is drawn on thin white paper and glued to the right edge of the beam for the rider (described later). The zero mark is located directly over the central knife edge.

To test for the beam's center of gravity, tie a nail to one end of a piece of strong thread and a weight to the other. Hang the beam from one end on the nail, and the plumb thread will pass through the projected center of gravity. Since the center of gravity may be assumed to lie on the vertical center line of the beam, the point where the thread crosses this center line is the center of gravity.

Pans. The supports are iron wire, bent and soldered. The pans are sheet copper disks. The knife-edge hanger is tin, bent double to hold the knife edge and soldered to a piece of wire bent to form the hook.

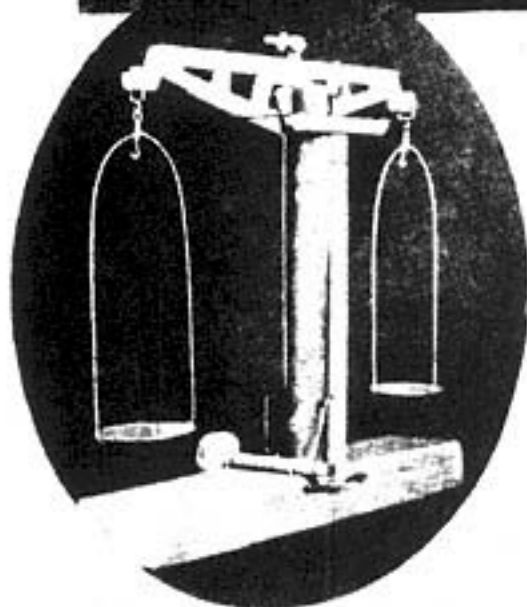
Oscillation arrester. A wooden T is made, 11 in. long, 4 in. wide. A U-shaped piece of wire is fastened to the bar of the T so the arms of the U extend far enough forward to support the beam. The stem of the wooden T slides up and down as illustrated through wire guides at the rear of the column.

Turning a knob to draw down the oscillation arrester, which is merely a pair of wire arms fastened to a T-shaped wooden device in rear

ALTHOUGH it will weigh to a fraction of a milligram, this beam balance did not cost me a cent. It was built entirely from scraps and salvaged materials.

Column. A 1¼-in. wooden dowel about 12½ in. long is set as shown at a slight angle in a hole bored in the base. A wooden bracket is fastened in a slot in the top to hold the knife-edge bearing, which is an iron washer with a nick filed across its upper face. Fasten the washer with small screws.

Beam. Cut from white pine. Bear in mind these facts: 1. The point of support (central knife edge) must be above the center of gravity of the finished beam, complete with indicator and adjustment screw, but the shorter the distance between these two points, the greater the sensibility or, as it is more



An adjusting screw is mounted above the arrester to limit its upward motion. A rubber band at the bottom forces it up to the adjustment screw, which passes through a small nut soldered to the bracket. A lock nut is also desirable. The arrester is drawn down by a cord wound around a dowel shaft, which has a knob on the front end. Friction holds the arrester until the knob is turned in the opposite direction. Bearings are made from two pieces of wire wound around the dowel and driven into the base.

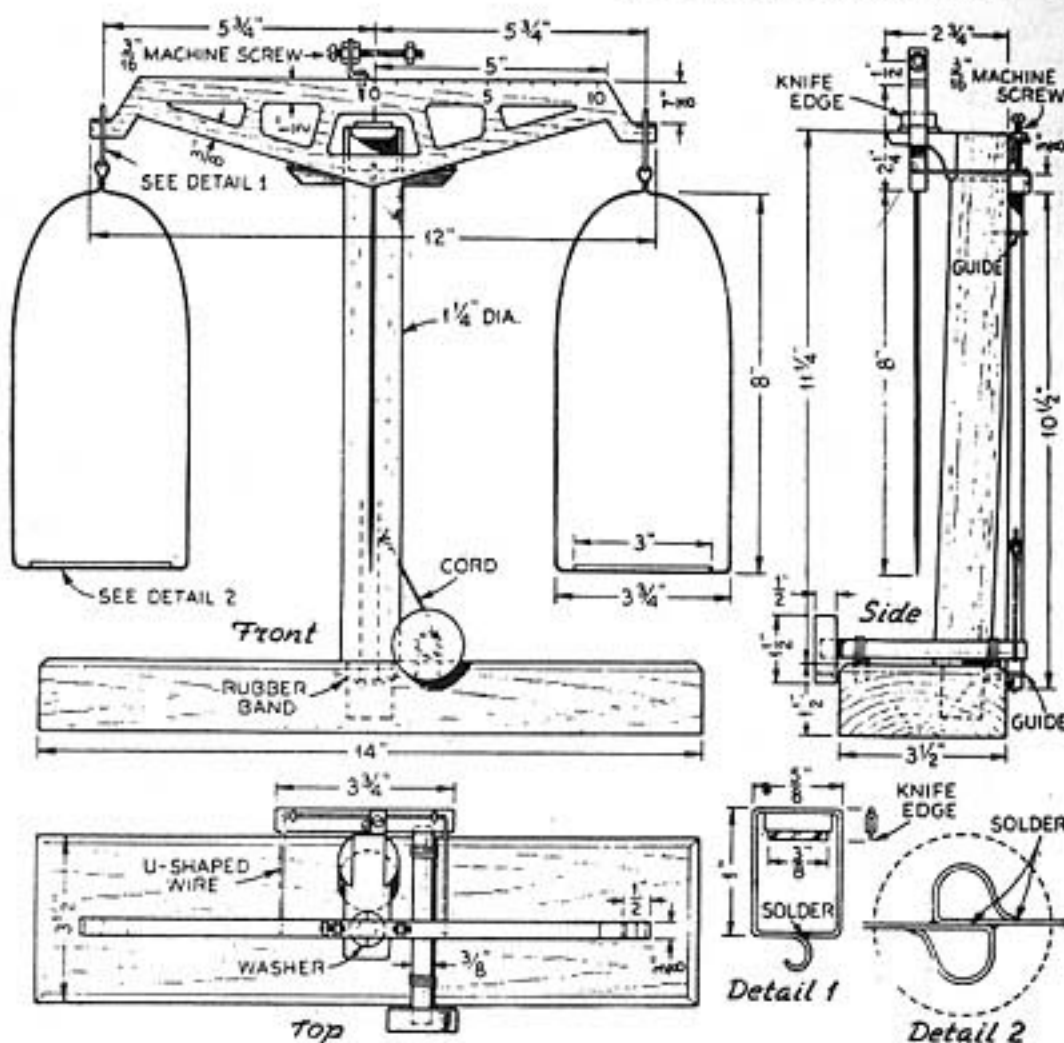
Varnishing. Two coats to wooden parts.

Assembly. Place central knife edge on its bearing and hang pan supports. Bring into equilibrium with the adjustment screw. Adjust arrester so that beam is supported, but not lifted clear.

On Bristol board, draw an indicator scale with twenty divisions, each 0.1 in., and glue near bottom of column.

The rider that slides along the right edge of the beam is a U-shaped piece of No. 40 enameled copper wire. Twist a small loop in the wire for moving it. It should be made larger than necessary, then reduced to such a weight that a 10-milligram weight on the left pan balances the rider on division 10.

For precise weighing, consult a text on qualitative chemical analysis. The rest point of the balance must be found in such work by averaging five consecutive turning points of the indicator. Three sets of readings are usually taken. The sensibility must also be determined—that is, the weight necessary to displace the rest point of the empty balance one scale division. Suppose the rest point is 10.3 with the rider on zero. Move the rider to division 3 (3 milligrams). Again determine the rest point. Let us say it is 8.8. The sensibility then is



Top, front, and end views of the complete beam balance, and two detail drawings, the first showing the knife-edge hangers and the second, the pan supports bent from wire

$$0.003 \text{ divided by } (10.3 - 8.8) = 0.002 \text{ grams or 2 milligrams.}$$

MISCELLANEOUS CHEMISTRY TIPS

by Kevin Christopher

There are some topics which don't belong under any particular heading of their own. This article is an anthology of such subjects.

A. Acrolein (See PMJB, page 39). As some of you have noticed, acrolein rapidly loses its potency if it is stored. The reason for this is that acrolein has a tendency to polymerize. This means that it reacts with itself to produce huge super-molecules with different properties than the acrolein. Nothing can be done to totally prevent this (except to add a few exotic chemicals), but the process can be slowed down by taking some precautions when storing it.

Keep acrolein in a cool, dark place in a dark or aluminum-foil-covered bottle. Also, don't store large amounts of acrolein in the same bottle. Use several small bottles and put them in a place where they're not likely to be shaken or handled too much as this accelerates polymerization.

Also, all the sources that I have say that acrolein is highly toxic, so take care when using it.

Besides Drano, which has additives in it to make it bubble and turn blue and all that crap, pure sodium bisulphate makes up several non-brand-name drain cleaners. It's also used as a pool acidifier. But, before you buy the stuff, read the label and be sure the bottle contains sodium bisulphate.

B. The Hydrochloric Acid Goody (PMJB page 40). This little goody is fantastic, but there seems to be some confusion about the mechanics of the thing. This is how it works:

Hydrochloric acid is a solution of a gas, hydrogen chloride, in water. When you heat the acid, the hydrogen chloride is driven off and picks up atmospheric moisture to form a white cloud made up of tiny droplets of hydrochloric acid. This happens at room temperature, but not as fast. That's why a bottle of hydrochloric acid fumes when you open it on a humid day. Anyway, when you put the aluminum in the acid, they react to produce hydrogen, aluminum chloride and great heat. The heat then drives the hydrogen chloride

into the air. So the gas that makes the air miserable is hydrogen chloride, not chlorine.

As is usually the case, now that we understand what happens, we can play around with it a little. Any way of heating the acid will produce the same effect.

A modification which will produce gas instantly can be made by using lye in place of the aluminum. The heat produced is terrific and the gas is evolved instantly upon addition of the lye.

C. Prussic Acid — In the PMJB, page 10, Kurt has drastically underestimated prussic acid. This is a very dangerous thing to do.

Prussic acid is one of the most potent poisons in the world and should never be made without a fume hood. It boils at 79°F (below body temperature) which means that if you hold a container of prussic acid in your hand long enough, your body heat will cause it to vaporize and you're almost sure to get a whiff of it. You won't know it either because prussic acid has only a faint odor of bitter almond (like peanuts, but sharper and more piercing). After making it, the chemical should be stored in a cool, dark place, NOT IN YOUR REFRIGERATOR, in a tightly capped dark bottle (See the PMJB for details). Also, you

should shower and wash your clothes after making it.

I kid you not; this stuff is that dangerous and you just can't be too careful around it.

D. Homemade Barometer — This goes right along with Don Cart's weather article, "Be Prepared," on page 555 of THE SURVIVOR. This barometer will give an indication as to whether the air pressure is going up or down over a period of time and, using Don Cart's chart, will enable you to predict the weather to some extent.

First, buy a large balloon from the dime store and cut it down the middle. Stretch one of the halves over the mouth of a mason jar and fasten it down with a rubber band. The seal between the balloon and the jar must be airtight for the thing to work. You may have to use glue. Anyway, once you get the seal airtight, tape either a soda or broom straw to the center of the balloon so that when the balloon is forced down, the other end of the straw will go up. This is the barometer.

To use the thing, first put the barometer somewhere that the temperature is fairly constant and it is out of the direct sun. This is where it should stay for as long as you intend to use it. Anyway, position it so that the straw points toward a wall. Place a piece of tape on the wall which has been marked with a line every eighth-inch and number the marks starting with "0" at the bottom going to about 25 at the top.

Finally, make a chart and hang it near the barometer. Write down the number of the mark that the straw points to every twelve hours. The higher the number of

the mark, the higher the air pressure. Now use Don Cart's weather article on page 555 to help you predict the weather.

E. Sulphur Dioxide — This is a nauseating gas, easily produced, which is very effective in clearing a room if you're not in any hurry as the gas is produced slowly by the following method:

Burning sulphur produces sulphur dioxide. Simply place a pile of sulphur on an inverted tin can and light with a match.

The use of the up-side-down can is important because sulphur melts as it burns and, without the metal rim of the can to contain it, the molten sulphur would begin to flow all around, setting things on fire. In general, put the sulphur on some shallow, rimmed and non-flammable surface.

Also, when placing this thing, take care to put it somewhere that it can't be seen (obviously). This is easy because sulphur burns quietly, giving off little light and though it catches slowly, once lit it becomes very hard to put out.

Another thing: Don't place the can in any depressions because sulphur dioxide is a very heavy gas and will fill the depression, putting the burning sulphur out.

All in all, this is very effective.

F. Modified Sulphuric Acid Process — On page 68 of the new, enlarged edition of the PMJB, on page 246 of the enlarged GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY is Kurt's process for making sulphuric acid from scratch. The idea is excellent and the principle sound, but I have a minor improvement.

Instead of the large siphon bottle which Kurt uses to draw the gas through the system, simply hook the tube coming from the bottle of concentrated sulphuric acid to a vacuum cleaner set for the lowest

possible suction. This provides the needed suction and does away with forever refilling the siphon bottle.

G. General Information on Information — I have several books dealing with improvised weapons and the like and, from these have drawn one grand and simple conclusion: That is, don't assume that the person writing the book knows what he's talking about. This includes army manuals, books after the fashion of THE ANARCHIST COOKBOOK and the article you're reading right now. I have run across books that were unclear, vaguely written and even downright wrong in some cases.

A case in point is THE COMPLETE CIA & SPECIAL FORCES IMPROVISED MUNITIONS BLACK BOOKS

These are dangerous books. Sure, they tell you how to make several high explosives from scratch, but then they leave you flat. They give no information about how to handle or store the explosives nor do they mention things like safety goggles or hand protectors. The books just leave you with a pile of high explosive and nothing more which is a very dangerous position to be in. In short, these "Black Books" were written for people who have a hell of a lot more experience than your average man when it comes to explosives and such related items.

As an example of what I'm talking about: In these books is a method for producing methyl nitrate, a liquid high explosive. However, the book fails to mention that methyl nitrate is more sensitive to initiation than nitroglycerine. It also fails to mention that methyl nitrate emits fumes which can be narcotic.

A HOMEMADE FUME HOOD

by Kevin Christopher

One of the main problems that the home experimenter has to cope with is the problem of ventilation. Chemical fumes can be highly toxic and can knock you down faster than you would believe.

I was thirteen when I first got interested in chemistry and it wasn't long after that when I began to experiment in my room. My chemical career was almost put to an abrupt end the first time I filled the house with hydrogen sulphide, the "rotten egg" gas. So, to prevent further friction with my parents, I devised this homemade fume hood.

In case you don't know, a fume hood is a device which draws off bad or poisonous fumes from a reaction and pumps them outside. It's a handy device to have if you do experiments with any regularity.

Basically, a fume hood is a box with some kind of suction attachment. The box is built by the experimenter to suit his needs, finances and available space. The suction is provided by an old vacuum cleaner gotten from a goodwill store.

The diagram is self-explanatory but let me go over the details to prevent errors and add comments when necessary.

First, notice that the suction is provided for at the top rear of the box and that the air intake is at the front bottom. The reason for this is that usually the fumes you want taken away are hot and will rise. So, as they rise, they are taken up into the vacuum cleaner to be replaced by cool, clean air at the bottom.

If you're going to be using a high-heat source such as a Bunsen burner or a pro-

pane torch, you might want to consider putting a piece of sheet metal on the inside top of the box to protect it from the heat. This isn't really necessary but it will prolong the life of the box. Before putting it in, give the metal a couple of coats of shellac to protect it from chemical action.

Notice that no dimensions are given to keep things general, but three-feet wide by three-feet high by two-feet back are about right for the box. Make the legs so that the opening in the front of the box is about as high as your stomach. The dimensions you eventually choose will be determined by your height, finances, etc. The material is one-half-inch-thick plywood and be sure to allow for the thickness of the wood when laying out your pieces. After cutting and drilling the wood, it is screwed together, but note that the pieces are not screwed to each other. Instead they are screwed into the legs of the box and into short pieces of two-by-four to add strength and to avoid splitting

the plywood. Coat all the joints with silicone glue before screwing the box together to help make it airtight. Silicone glue can be gotten at most hardware stores and is the kind with a small sample of glue on the package.

After the box is screwed together, more glue is smeared into the joints and allowed to dry. Then the entire box, both inside and out, is given two coats of flat black paint. This makes chemical spills easier to detect as most chemicals are light in color. After the paint dries, coat the box, again both inside and out, with at least three coats of shellac. If you can get any paint specially made to resist chemical attack, by all means, use that instead.

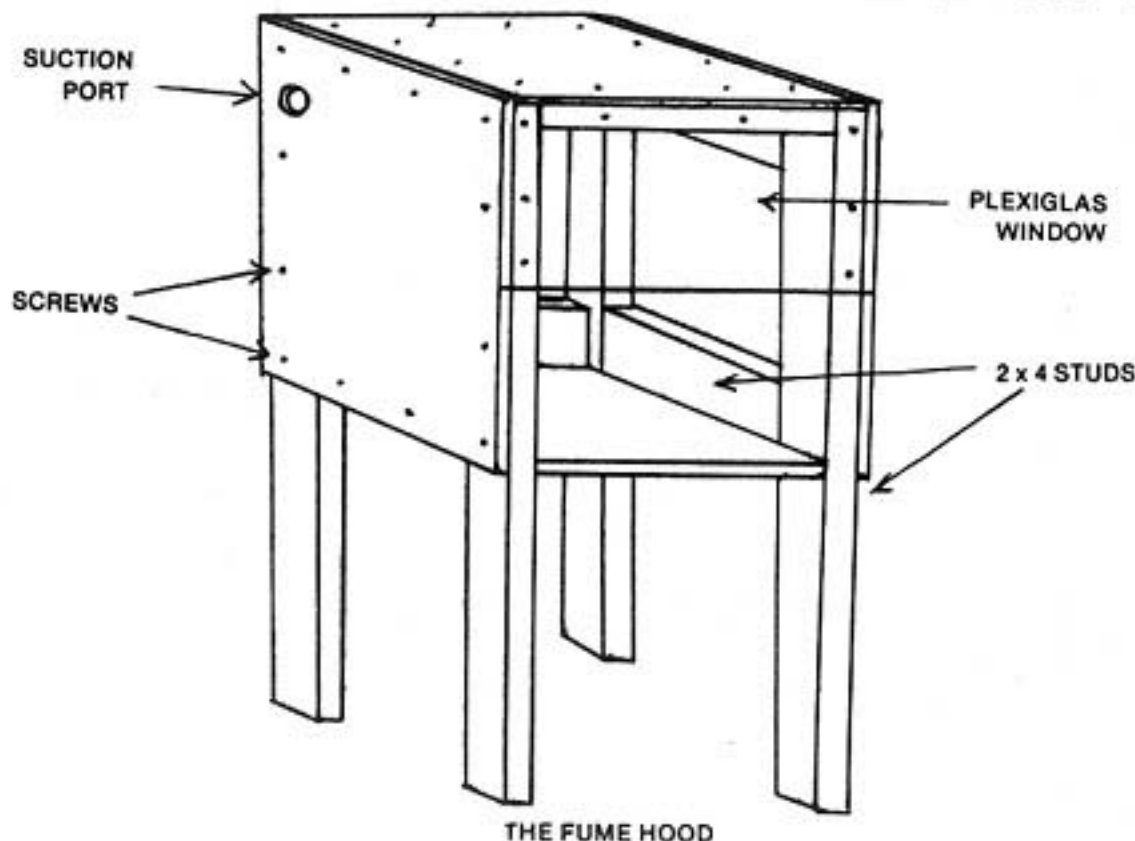
When the shellac dries is the time to put in the plexiglas window; not glass or even safety glass, but plexiglas. If you use a glass window and something explodes inside the box, you'll be cut to shreds by flying glass. The plexiglas should be around a quarter-inch thick and the wood-to-plexiglas seal should be made airtight with silicone glue before the window is screwed into the box.

To do this, the plexiglas is cut to the proper size (the window should cover about half of the front) and is then drilled along the three edges with holes just slightly larger than the screws themselves. Then, the edge of the box where the wood will contact plexiglas is liberally smeared with silicone glue. Position the window and screw it into place. Note that, like everything else, the window is screwed into the two-by-fours and not into the plywood walls.

Two notes: The fume hood I originally made was a free-standing unit with legs. But, if you want, you can make a table model just by shortening the legs. Secondly, you'll find that your life will be easier if you first drill small holes in the box pieces and studs at the places you plan to put screws. This further reduces the chance of splitting the wood.

As I've said, the suction is provided by an old vacuum cleaner gotten from a goodwill store. Don't use your household vacuum cleaner. Vapors can get caught in the cleaner and then be released when your wife starts to clean the kids' room. Anyway, the bag and air filters are removed and the cleaner is ready. Just stick the suction hose an inch or so into the hole in the top rear of the box, place the cleaner outside (which can be done by tying a good, strong rope around the handle and hanging the whole thing out a window) and you're ready to go.

To use the hood, your chemical apparatus is set up inside the hood and the vacuum cleaner is turned on. Now, the chemicals are put into your experiment.



It's important to start the suction before any chemicals are mixed because some reactions that require heating proceed slowly at room temperature. So, if you mix the chemicals before turning on the suction, you could be overtaken by fumes. Anyway, after the chemicals are mixed, go on with your experiment as usual.

When the reaction has reached completion, the suction is left on while everything is washed, sealed up, neutralized and generally made safe. Remember that all this is done inside the fume hood. Then remove the vacuum cleaner hose from the hood, still running, take it outside with the cleaner and let it run for another fifteen minutes to help clear it of residual fumes.

Obviously, when using the hood, you're going to take more care when working with a deadly poison like prussic acid than you are when working with something that's just irritating, like acrolein. Use common sense.

There are two difficulties that readily come to mind: First, if there is any danger of explosion, don't use the hood. Do the experiment outside instead. The reason

for this is that if your experiment explodes inside the hood, the explosion will travel along the lines of least resistance which is out the front opening. That's right about where your stomach will be. So no explosives in the hood.

Secondly, we have the problem of alcohol lamp flutter. Sometimes, the incoming draft at the bottom will cause the flame to flutter, drawing off its heat. The obvious answer is not to use an alcohol lamp. Another answer is to reduce the suction and thus cut down the draft. But, this method reduces the rate at which the bad fumes are carried off, so take care in this solution. Or you could arrange some kind of cardboard wind screen around the lamp. Use your imagination.

So, this is the fume hood. Get to know it well before you actually prepare very deadly things in it. And even though it can be used indoors, I strongly recommend that you never experiment inside, even with the fume hood. I did it only in my younger, more dimwitted years.

How to Keep Flies Out of the House

There are fly swatters, fly papers and various kinds of poisons for getting rid of house flies, but all of these have some disadvantages. A better and more effective way is to take a small clean sponge and place it in a dish after dipping in very hot water. Immediately after dipping the sponge, apply a few drops of oil of lavender on it. Flies do not like the odor, and will leave any place where it is present. If the sponge is moistened about twice a day, flies will not come around.

Water of every kind, except rain water, will speedily cover the inside of a tea-kettle with an unpleasant crust; this may easily be guarded against by placing a clean oyster-shell or a piece of stone or marble in the tea-kettle. The shell or stone will always keep the interior of the kettle in good order, by attracting the particles of earth or of stone.

HOMEMADE LABWARE FOR THE AMATEUR

by Kevin Christopher

To many intelligent and cultivated people not specifically instructed in chemistry, the word recalls confused memories of colored liquids, glistening crystals, dazzling flames, suffocating fumes, intolerable odors, startling explosions and a chaos of mystifying experiments. The word also conjures up visions of Boris Karloff behind a confusing array of retorts and condensers, furnaces and crucibles together with innumerable bottles filled with solids, liquids and gasses. Moreover, this whole bewildering paraphernalia is connected by glass tubing of eccentric curves, displayed in incredible confusion and meaningless array.

Chemistry doesn't need to be this way. Don't be taken in by those who are convinced that chemistry has to be expensive and complicated. It doesn't.

This article is just chock full of equipment that you can make out of junk and most of it works just as well as that expensive, store-bought stuff. Using this article and the processes and techniques described in GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY, you shouldn't have any trouble at all with kitchen chemistry.

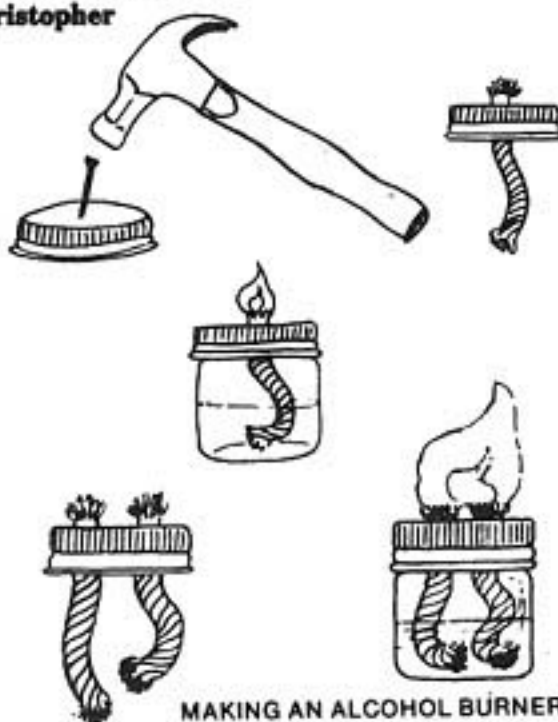
Heat Sources — The classic laboratory heat source is the good, old Bunsen burner but, unless you have a source of gas that you can readily hook into, they are impractical for kitchen chemistry. However, a propane torch, picked up at any hardware store, makes an excellent substitute.

Another classic source of heat is the alcohol burner. These are very easy to make. You'll need a small bottle with a metal lid and a piece of clothesline rope about four inches long.

Punch a small hole in the lid of the jar. The hole should be small enough that you have to force the end of the clothesline through the hole. Force the rope through the top side of the lid leaving about a half-inch sticking through the top. Now, fill the bottle with alcohol, screw on the lid and it is done.

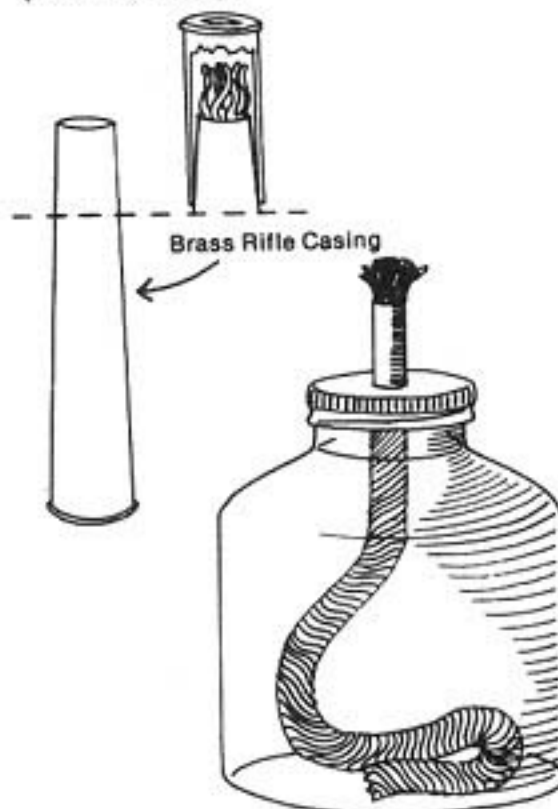
Note: The clothesline should be of the type that has many soft cotton fibres on the inside. You can also use a piece of cotton bath towel as the wick, but make sure that the hole in the lid is tight in any case.

By the way, you can put more than one wick in your burner if you need more heat or want to bend glass tubing. If the wicks are bent close to each other (within half an inch), they will produce one large flame. Make the holes in the jar lid about an inch apart.



MAKING AN ALCOHOL BURNER

Alcohol lamps usually need a cap to prevent all the fuel from evaporating between uses. An old fountain pen cap placed over the wick may serve the purpose. So might a 35mm film canister or the lid from another jar. If a brass rifle cartridge is available, it can be used to make both the alcohol lamp and its cap by cutting it in a suitable place with a hacksaw (see illustration).



AN ALCOHOL BURNER MADE FROM A SPENT CARTRIDGE

One word of warning: Never carry a lit alcohol burner. If you drop it and the thing breaks, it will act exactly like a Molotov

cocktail.

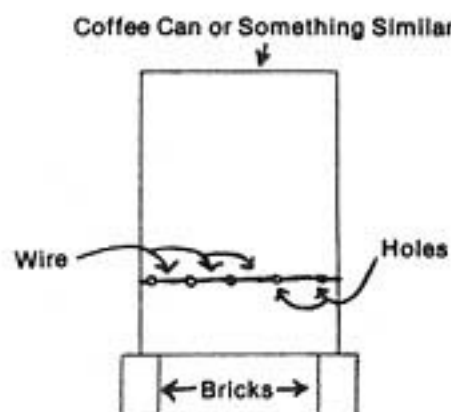
The best fuel I know of is "Mr. Thinzit Denatured Alcohol" gotten at any hardware or paint store. Rubbing alcohol and the like will work, but not as well as "Mr. Thinzit" because rubbing alcohol usually contains water.

Another good heat source is the coffee-can furnace. This is strictly an outdoors device and, with the proper modification, can bring objects up to a bright-red heat for several hours.

As you might have guessed, you need a coffee can or something similar. First, remove both the top and bottom so you have a large, metal tube. Punch several quarter-inch holes all around the can about an inch from the base. The holes should be about an inch apart and can be made with a nail. Now, get some picture-hanging wire, some antenna wire or even some bell wire and thread it in and out of the holes you just made to form a support for the charcoal. Thread the wire through the can enough so that nothing larger than a half-inch can fall through. That's all there is to it.

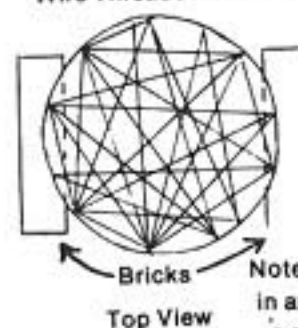
To use the furnace, set it on a barbeque grill or a couple of bricks so that air can flow up through the base and get to the charcoal. Fill it about three-quarters full

THE COFFEE CAN FURNACE



Side View

Wire Threaded Inside Can



Top View

Note that the wire is threaded in and out of the can to form a support for the charcoal

with charcoal, place the object you want heated in the center of the coal and then fill the rest of the furnace. Light it the way you'd light a barbeque (ie. spurt some lighter fluid on the charcoal and toss on a match). **BE SURE TO USE THE FURNACE ONLY IN A WELL-VENTILATED AREA.** It will reach full heat in about thirty minutes and, left alone,

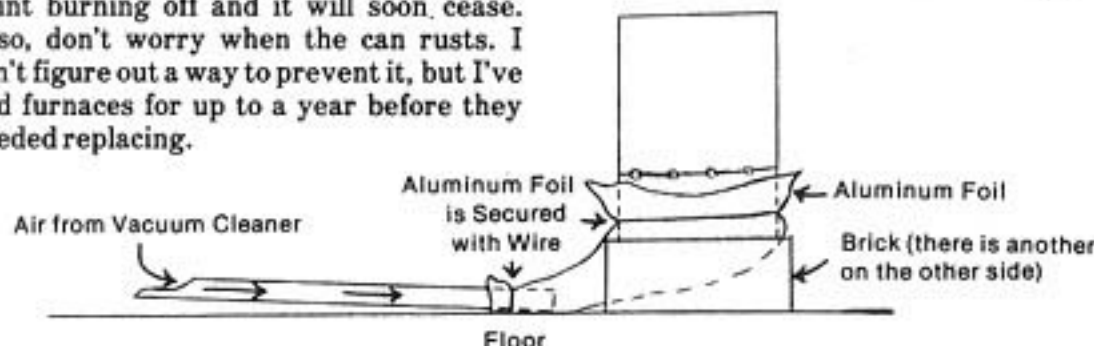
will continue to burn for an hour at a dull-red heat.

To get even more heat, you have to convert the thing into a miniature blast furnace. After you've finished threading the support wires, wrap several layers of aluminum foil around the very bottom of the furnace (closest to the charcoal support wires) such that about an inch of the foil is around the can itself and the rest hangs below the can. Then secure the foil to the can by wrapping tightly with wire.

Now, get a vacuum cleaner and arrange it so that air is blown, not sucked, through the hose. Form the aluminum foil around the hose and wrap it tightly with wire. Set up the furnace on a couple of bricks so that air blown by the vacuum cleaner has an unobstructed path. Fill it with charcoal, light it and start up the blower. In about thirty minutes, the furnace will reach bright red heat.

Both types of furnaces seem to work best on charcoal the size of peach pits or a little smaller. The "blast furnace" eats this like no tomorrow, but the heat is tremendous.

When first run, this thing will smoke like the devil, but don't worry. It's just the paint burning off and it will soon cease. Also, don't worry when the can rusts. I can't figure out a way to prevent it, but I've had furnaces for up to a year before they needed replacing.



THE COFFEE CAN BLAST FURNACE

Also, don't overlook heat sources such as hot plates, the light-bulb stove on page 528, candles or even your kitchen stove.

Containers — The kind of containers that I'm going to be talking about are used only for chemical storage and are not to be heated. We'll get to those later.

I don't really need to tell you about the kinds of containers available to the home experimenter. Beer and soda bottles, Mason jars and a myriad of shapes and sizes in food bottles are just a few examples of what's available.

To prepare bottles for storing chemicals amounts to little more than giving them a good washing in very hot, soapy water; letting them soak in clean hot water first to get the labels off. Be sure to get any remaining label glue off (you may have to use lighter fluid). Anyway, after giving the jars a good scrubbing, let them soak in clear, hot water for about an hour. Then dry them with a towel and let the jars sit up-side-down on a towel to air dry. Don't forget to do the lids right along with the jars, but remove the cardboard inserts first and put them back into the clean lids

after you've gotten the inserts as clean as you can with a damp paper towel.

If you can still smell the original contents either in the jars or their lids, don't worry. You can still use the bottle. In kitchen chemistry, your chemicals, originally meant as garden or supermarket chemicals, aren't going to be all that pure to begin with, so you won't have to worry about the possible contamination from the "dirty" jar.

When storing a chemical in a new container, make sure that the chemicals don't react with either the container or its lid. Also, the capacity of the container should not greatly exceed the quantity of chemical to be stored. However, the container should be large enough to be handled easily and not readily misplaced. Any container should be capable of being tightly closed to prevent contamination, leakage, or evaporation and it should not be able to tip easily. Your containers should be cleanable and durable. Reserve wide-mouthed bottles for solids and narrow-mouthed bottles for liquids. Green, brown or amber bottles should be provided for silver compounds and other light-

sensitive materials. Beer bottles serve this purpose well.

Rubber Stoppers — Now here's a problem. Beer and soda bottles have non-reusable caps. The only thing I can suggest is to get to a drugstore that has one of those Saf-T-Pak chemical displays. They're scattered all over; at least here in Ohio though I don't know about other states. Saf-T-Pak sells labware at a reasonable price although their chemicals are ridiculous. Anyway, you can get rubber stoppers there. If you don't have a Saf-T-Pak near you, either ask your friendly druggist or order them from a chemical supply house.

You might also try cork stoppers sometimes sold at supermarkets.

Beakers — These are cup-like containers used for heating and manipulating chemicals. You can usually find workable substitutes around the house. A household pyrex measuring cup, for example, makes an excellent substitute if you take care when heating it. Never heat any glassware, except pyrex test tubes, over an open flame. Instead, heat through a wire

gauze (a piece of metal window screening is fine for this). But, even then, you should heat gently.

Regular drinking glasses are a good substitute if you don't need to heat them or measure with them.

Graduated Cylinder — This is a tall, thin glass tube used for measuring liquids. A good substitute is a pyrex baby bottle; most of which are marked in both cubic centimeters (cc.) and fluid ounces although they aren't deadly accurate.

Light-bulb Flask — This is a pyrex chemistry flask made out of (you guessed it) a burnt-out light bulb. Being pyrex, it can be safely heated over an alcohol lamp (but use a screen as described under "Beakers").

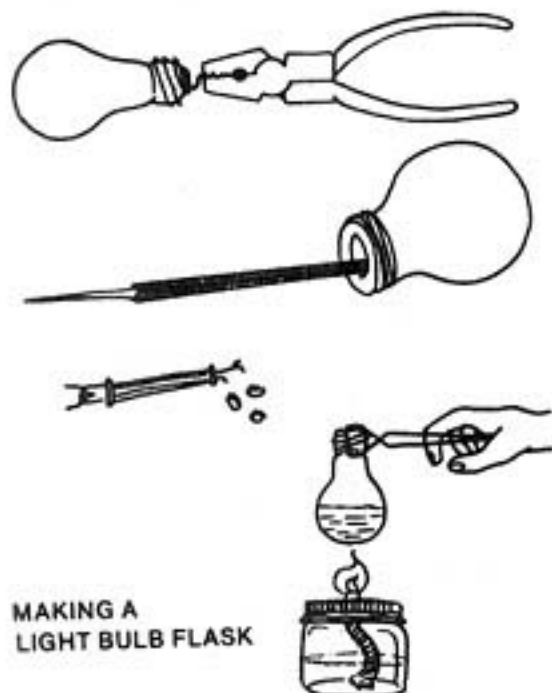
It's a good idea to wrap the bulb in an old towel or something while working on it. Begin by lifting the small metal button in the center of the bulb bottom with a knife. Bend this up until it can be grasped with a pair of pliers. This should expose the wire to which it is connected. Break the button away from the wire with a twisting motion. This will expose the hole in the center of the black insulation. Carefully loosen and remove this insulation which may require you to crack it into several pieces with the pliers. Be as careful as possible not to bend the metal shell. The next operation requires a lot of care and you may break a few bulbs before developing enough skill. Hold the wrapped bulb firmly and, using the top end of a rattail file, puncture the bulb through the opening in the base with a quick motion. The glass rod which supports the bulb filament should drop into the bulb. Next, file back the jagged glass in the neck of the bulb and fish out the support rod and other junk that fell in. The flask is now ready to use.

If the metal shell which forms the top of the flask has been bent, it can be made round again by turning it on the end of a broom handle. The round metal shell enables tight fits to be made with cork and rubber stoppers.

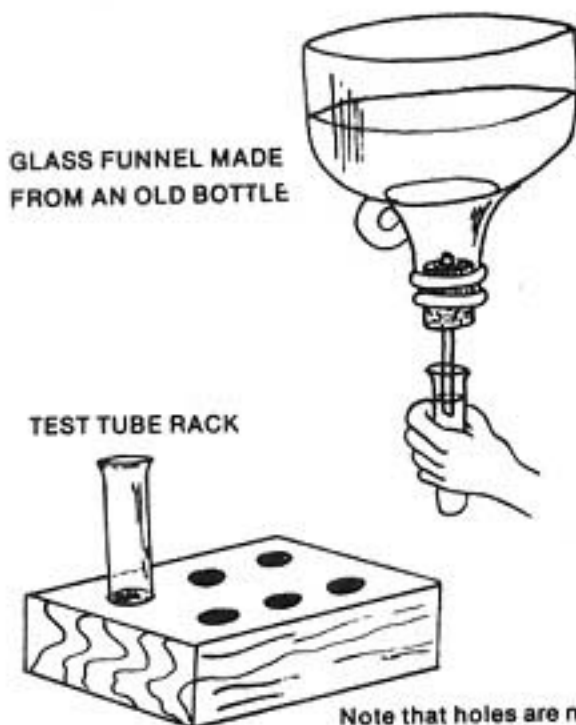
The above can be done with all kinds of light bulbs; either regular household bulbs or special purpose lamps (ie. sunlamps and the like). Some bulbs are cone-shaped and are very useful because they stand up by themselves. Not so with ordinary, round-bottomed light bulbs.

Glass Funnel — The best substitute I know of is made from an old bottle. See page 116 of "The Survivor" and also page 1 for an alternate method of cutting the bottle.

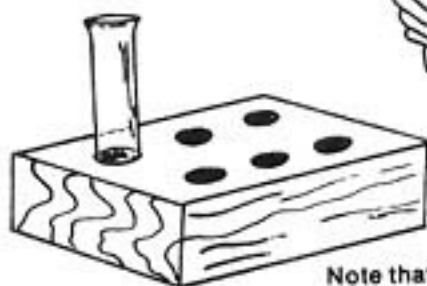
Test Tubes — There is no hard and fast substitute for these that I know of. Light-bulb flasks are the best thing going although you might try olive jars or pyrex baby bottles. But, if you really need test

MAKING A
LIGHT BULB FLASK

tubes, you'll have to order them from a chemical supply house.

GLASS FUNNEL MADE
FROM AN OLD BOTTLE

TEST TUBE RACK



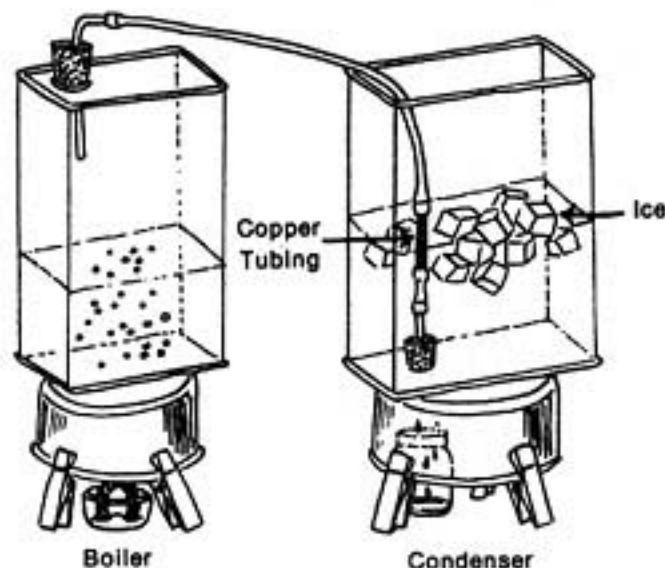
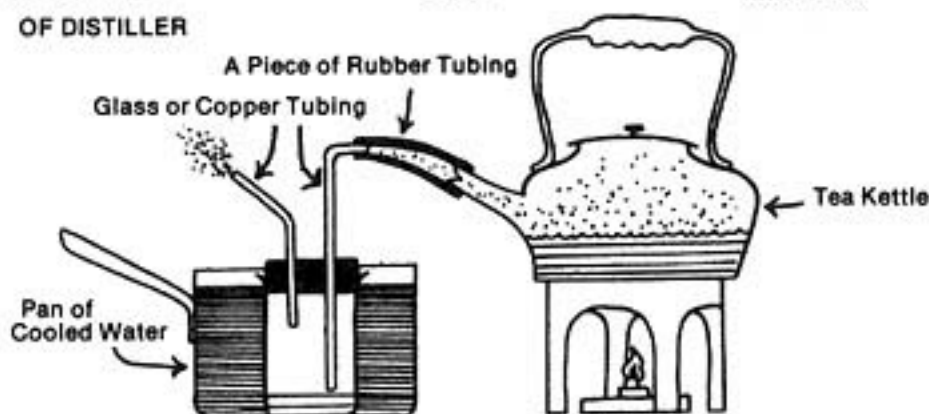
Note that holes are not drilled all the way through

Test Tube Racks — These can be made quite simply from a two-by-four. The illustration should explain the construction details. The holes are drilled so that they are just a little larger than the test tube and they do not go all the way through. If you have trouble drilling the partial holes, then drill all the way through and glue a piece of hardboard to the bottom.

Test Tube Holder — These are used to hold flasks and such while heating them. They can be bent from heavy wire (see GWBC; p. 370) or you can just use a large, spring-type clothes pin as a holder.

Glass and Rubber Tubing — Again, there is no hard and fast substitute that I know of. You might try Saf-T-Pak or a chemical supply house. Plastic aquarium hose works in some cases, but take care

ONE TYPE OF DISTILLER

ANOTHER TYPE
OF DISTILLER

because some common lab solvents will dissolve it.

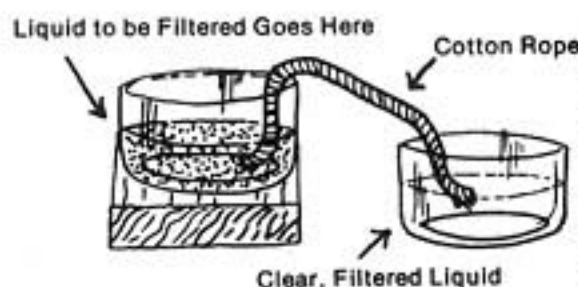
By the way, if you get some glass tubing, the PMJB (enlarged edition) and GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY both have information on working with it.

String Filter—This is an old trick dating back to the middle ages. It does an excellent job of filtering but it takes a couple of hours.

Arrange two jars such that one is about an inch higher than the other. Pour the liquid to be filtered into the higher jar along with one end of a clean foot-long cotton rope. Place the other end in the lower jar and wait. The pure, filtered liquid will flow through the rope into the lower jar, leaving the insoluble matter in the higher one.

Don't use this with volatile solvents as they usually evaporate before they're done filtering. Also, be sure to use a clean rope. Wash it out afterwards and you can use the same rope over and over again.

STRING FILTER



Filter Paper — A good substitute is paper towelling, but use the kind that doesn't have any holes. See GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY for details on filtering.

Distillers — The diagrams illustrate several types. You should be able to pick up the general principles such that you'll be able to design a distiller to suit your situation. Just make sure that what you're distilling doesn't dissolve or react with any part of your distiller.

Measuring Spoons — These are used to measure out chemicals. A plastic spoon set from the supermarket is an excellent substitute.

Crucible — A good substitute for a porcelain crucible is a pipe cap and a suitable plug. Be sure to drill a tiny hole in the plug (which will be the cover to your crucible) to allow any gas to escape. A larger crucible can be made out of a piece of pipe capped on both ends. Again, be sure to drill a gas-escape hole.

Don't use these metal crucibles with oxidizing agents as they tend to chew holes in the pipe.

Tripods and Supports — These are the things that flasks and such sit on while being heated. They're made out of tin cans and you might want to make several of different sizes.

Cut off the ends of a suitable can so you have a metal tube. Place a block of wood inside the can and punch several holes with a large nail about an inch from the end of

the can. You should have at least six. Then, enlarge the holes to about half-an-inch with a ball-point pen and attach three spring-type clothes pins as shown so that the tip of the burner wick is about two inches from the bottom of the flask.

Or you might want to make a tripod by cutting the can with a pair of tin snips as shown.

Note that a square of metal window screen is placed over the tripod when glass containers are to be heated. Always use a wire screen in this manner regardless of the kind of support used and never allow open flames to come in direct contact with glassware other than pyrex test tubes.

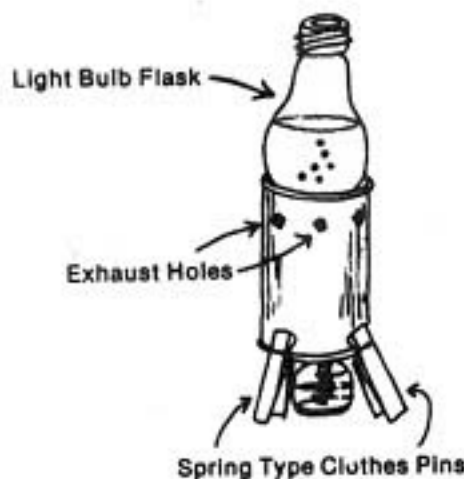
Balance — This is one of the few things that you really can't do without. I plan to do an article just on balances in the near future so, until then, buy a cheap postage scale calibrated in both grams and ounces, if possible.

Drying Oven — A lot of formulas in **GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY** require dry chemicals. The most obvious way of drying them is also the best way. Use your kitchen oven. Spread the chemical or plant out in a large, glass tray and put it in your oven. Inspect every half-hour or so.

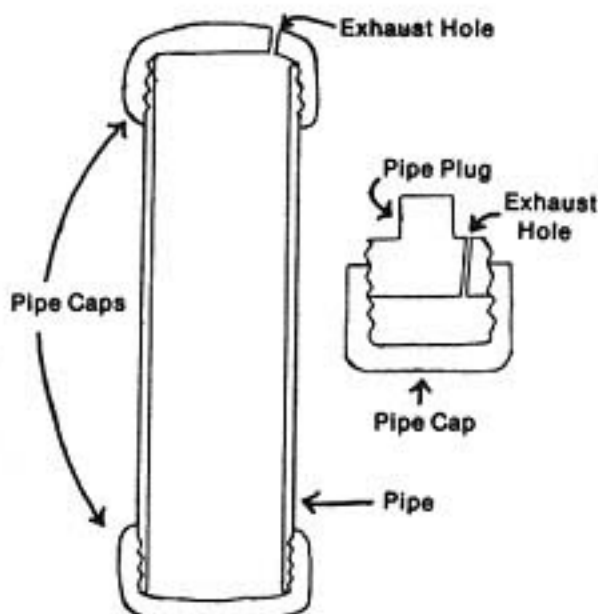
MAKING A CLOTHES PIN TRIPOD



A piece of wood is inserted when making the exhaust holes in the can



CRUCIBLES

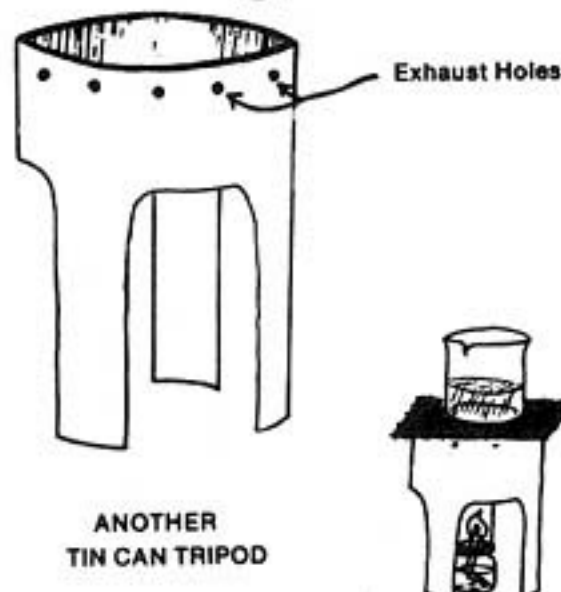
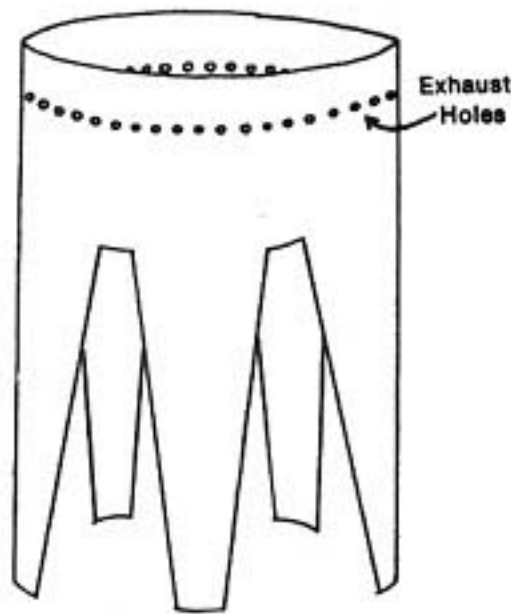


I can't get any more specific than this as every chemical or plant requires a different time and temperature. You'll just have to experiment.

Beaker and Crucible Tongs — These are used for handling hot beakers and crucibles. A passable substitute is a pair of kitchen tongs gotten at the supermarket. Or tongs can be bent out of coathanger wire as in **GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY**.

These are some lab items that you can make from junk. This isn't meant to be a complete list by any means. It's meant more as a thought provoker and as an example of making what you need out of what you have.

A TRIPOD CUT FROM A TIN CAN



ANOTHER TIN CAN TRIPOD

CHEMICAL MISCELLANEOUS

By Kevin Christopher

A. Testing Gasoline for Water—Water in gasoline can cause a lot of problems for a survivor.

First, you'll need some copper sulphate. See part III of "On Finding Chemicals" for the sources of this stuff. The chemical you will get should be a very pretty shade of blue. This means that the chemical contains water of hydration. When it's dehydrated, the stuff is absolutely white. The dehydrated copper sulphate will turn blue when it comes in contact with water again and therein lies the basis of our test.

Dehydrating the chemical amounts to little more than heating it until it turns white. The diagram illustrates one method of dehydrating a small amount of copper sulphate on your kitchen stove (by the way, this method can be used to dry almost anything). Or, you can just heat the chemical in a test tube. At any rate, test the gasoline only with freshly dehydrated copper sulphate.

Put just enough into a small, dry pill

vial to cover the bottom and fill the rest with the suspect gasoline. Shake once or twice and if the dehydrated copper sulphate turns blue, the gas contains water. If it remains white, the gas is all right.

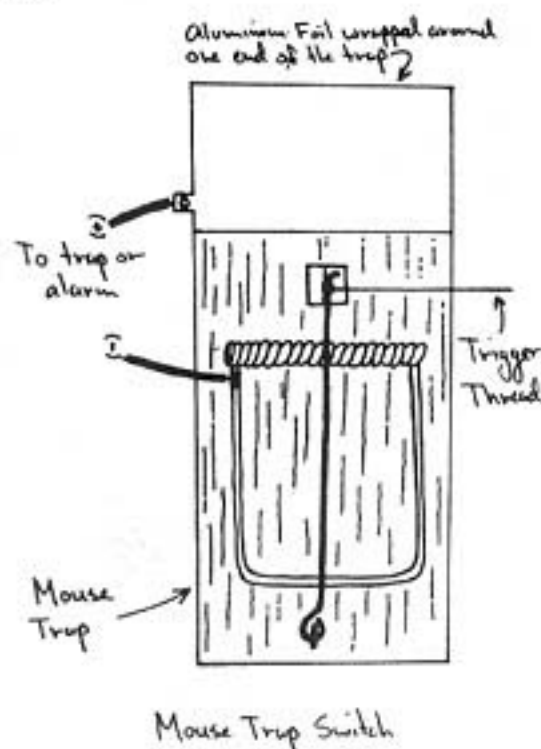
B. Geological Survey Maps—Geological survey maps are just perfect for keeping tabs on what's around your survival shelter. They can also be used to study a possible survival home from far away as in Kurt's article "Studying your Survival Home from Afar" on page 20.

Geological survey maps are put out by our government and are on a scale of 1:24,000. This means that they are detailed enough to show tiny foot paths, walls and small creeks. They also show elevation and contours.

The addresses for ordering them are: East of the Mississippi: U.S. Geologic Survey, Washington District Section, 1200 South Eads Street, Arlington, Virginia 22202; West of the Mississippi: U.S. Geologic Survey, District Section, Federal

Center, Denver, Colorado 80225.

When you first write, ask for the free index map for the state you're interested in.

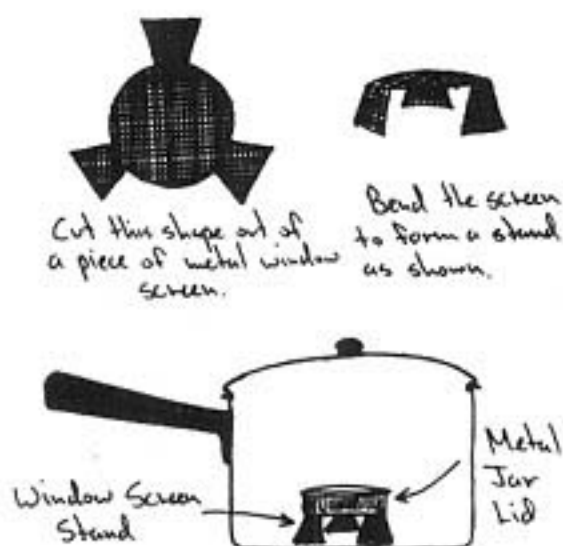


C. Mouse Trap Alarm—This is something I read about a couple of years ago which has proved to be very effective as a burglar alarm or booby trap trigger.

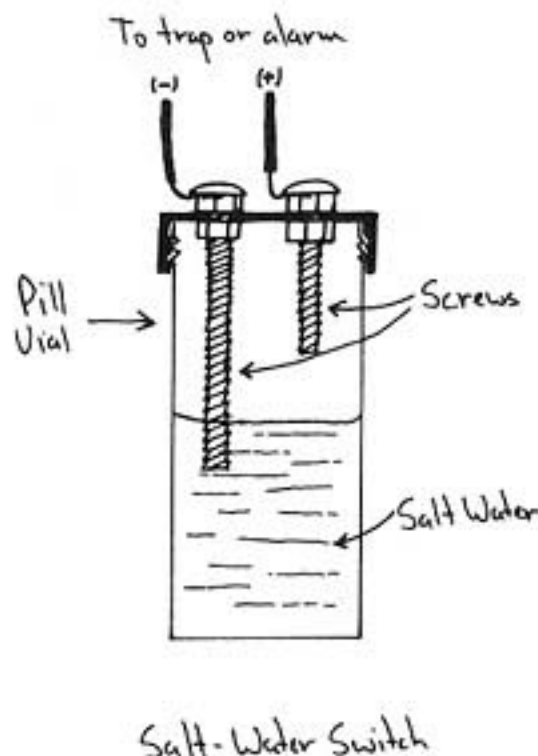
All you need to construct the actual switch is a mousetrap, some aluminum foil, wire and a piece of black thread. The diagram explains the hook-up. Note that the aluminum foil is wrapped around one end of the trap so that when the thread is tugged, the trap closes and completes the circuit.

I recommend a black thread because it's impossible to see at night and almost as difficult to see during the day.

To Dry Chemicals:



Another simple burglar alarm switch can be made from a common pill vial and a little salt water.



Dissolve as much table salt in water as will dissolve and set up the switch as in the diagram. When anyone knocks the vial over by tugging the string, both screws will be in the salt water and complete the circuit. Naturally, this won't work in freezing weather.

D. Sources of Labware—Many devices in the PMJB, SURVIVOR etc. call for lab equipment. The price of good labware is skyrocketing.

I've found that the better part of all labware can be made at home or else household substitutes such as blenders, mixers, glass ovenware, etc. can be found. For examples of the former, see "Home-made Labware for the Amateur." But, as for the latter, brand new mixers and blenders are very expensive. So, for these, just go to any Goodwill or Salvation Army store. They stock old, but still functioning kitchenware for very little. This is just the kind of stuff that the kitchen chemist is looking for.

E. More on the Flame Thrower (See page 18 of the PMJB)—Recently, my flame thrower has begun to drip alcohol onto my hand whenever I squeeze the handle. This, I'm sure you'll agree, is highly undesirable seeing that a flame is only inches away.

The problem was that the nozzle that screwed onto the sprayer had somehow expanded and gotten too big for the sprayer threads. It might have been caused by the action of the alcohol on the plastic over a long period of time. Just in case, watch out for this.

I solved the problem with silicone glue. First, unscrew the nozzle, tube and all,

from the main portion of the sprayer. Then, coat the part of the sprayer mechanism which comes in contact with the screw-on nozzle with silicone glue (try to avoid any excess. Use just enough to cover the threads and no more). Immediately screw on the nozzle and adjust it so that it will spray a fine stream. Let everything stand a while to dry. The flame thrower will no longer leak.

The only problem with this solution is that since the nozzle is now permanently attached to the sprayer, you can't unscrew it for storage.

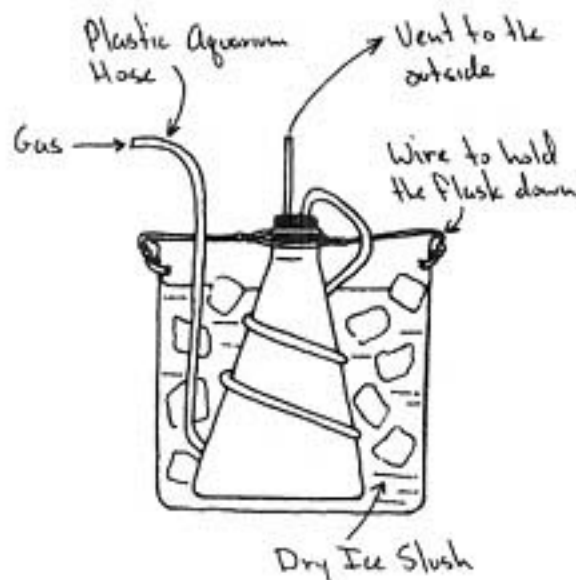


F. Producing Intense Cold—This is something that might come in handy to quick-freeze things. It will produce a temperature of around minus 78.5 degrees C. (or minus 110 degrees F.) using dry ice and acetone or methyl alcohol. See "On Finding Chemicals" for the sources of these.

About the dangers of dry ice: First of all, don't store or use it in a closed room because as it evaporates, the carbon dioxide will replace all of the oxygen in the air and cause you to drop dead. Secondly, dry ice is very cold and will instantly freeze to the skin, creating blisters and burns. So, handle the dry ice with tongs or thick gloves.

To get the cold into a form that can be readily absorbed by something requires you to make a slush out of the methyl alcohol or acetone and the dry ice. Neither of these liquids will freeze at so low a temperature and will absorb the heat from anything that it comes in contact with.

First, break the dry ice up into peach-pit sized chunks with a hammer. To avoid flying pieces of dry ice which could be disastrous (if one got in your eye, for example), cover the dry ice with a dishtowel or something before you begin pounding.



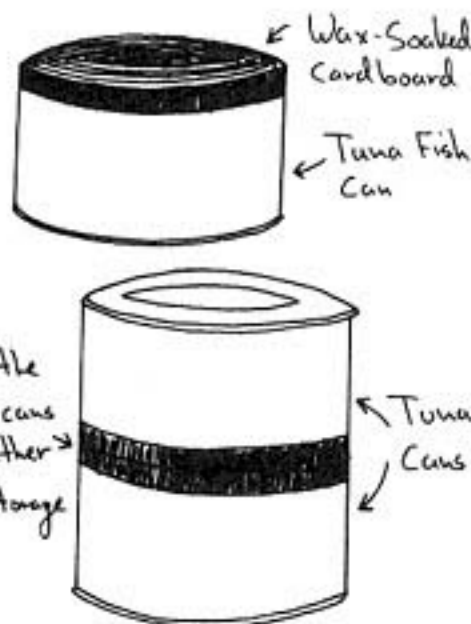
To Liquefy Some Gasses:

Wear safety glasses and heavy gloves just in case. Then, toss the pieces, a couple at a time, into a half full container of methyl alcohol or acetone. At first, the liquid will bubble violently. Keep putting in chunks until you have a thick, slushy mixture of dry ice and liquid. It is now ready.

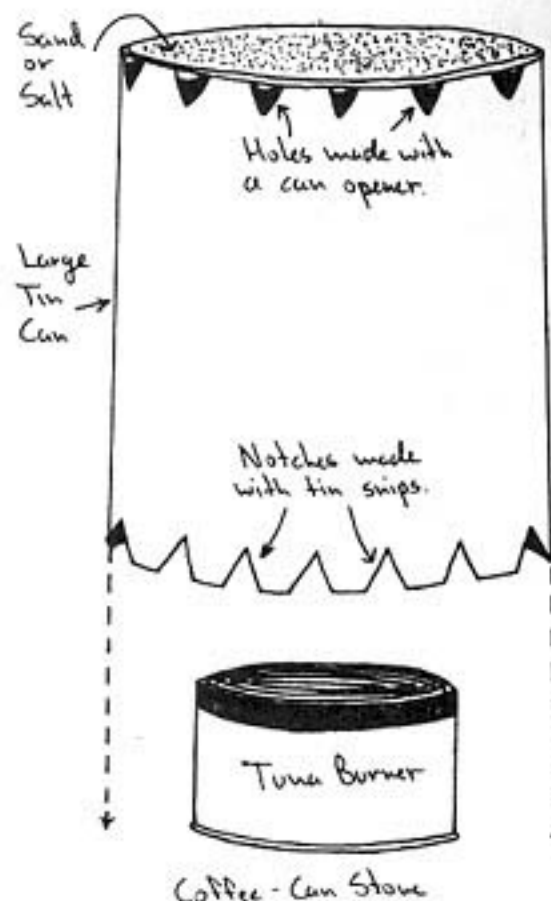
For some interesting things to do, try immersing a flower in the slush for about a minute and then hit it on a table top. It will shatter as if it were made of glass. Next, try a hot dog or a piece of rubber

tubing.

This mixture can also be used as a coolant in some reactions or it can be used to liquefy certain gasses. A couple which will liquefy at the temperatures we're talking about are sulphur dioxide (B.P. -10 degrees C.) and hydrogen sulphide (B.P. -60.2 degrees C.). The diagram illustrates a possible set-up to liquefy these gasses. If you're really interested in this, look up



The Tuna-Fish Burner



some other possible gasses in THE CONDENSED CHEMICAL DICTIONARY (See "Laboratory Safety" on page 1030).

ON FINDING CHEMICALS

by Kevin Christopher

A major problem facing anyone interested in kitchen chemistry is where to find chemicals to work with. Often, the kitchen chemist lives in a small town or out in the boondocks where commercial chemical companies are few to be found. Or, he could live in a big city but can't find a place which will sell to him.

So, what options are left open to him? He must either find a chemical company which will sell to him, find chemicals in the things readily available or forget about kitchen chemistry.

PART I - FINDING A CHEMICAL COMPANY

To those of you who live in a big city, you've got it pretty much made. In any large city, there is always at least one company that caters to hobbyists, although most don't.

To find the company, first call every place listed in the yellow pages under "Chemicals." Explain that you're a hobbyist who's just moved in from out-of-state and are looking for a place to buy chemicals and labware from. If you get a negative reply, always ask if they know of any place that does cater to hobbyists.

This is where you'll get most of your good leads. Of course, always be polite, even if you do end up with a complete nothing.

By the way, you'll almost always get a secretary or someone like that who doesn't know beans about chemistry, so it's not likely that you'll be asked any questions. But, just in case, you should always have a believable back-up story ready. A good one is that you want to try out some processes that you found in an old formulary. This will set up a need for a wide variety of chemicals. If they get more specific, just quote something harmless from GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY. Never, ever just hang the phone up in their faces! The very fact that they're asking questions means that they're considering your request. Hanging up will completely ruin your chances and probably the next guy's as well.

So, what if you call all of the chemical companies in the phone book and still end up with nothing? What I did was to call "Action Line." This is a column in most big-city newspapers that helps people like us with such frustrating little problems.

Write or phone the column and explain that you're a hobbyist who's just moved in from out-of-state and would like to find a place that sells chemicals and labware to individuals. They are usually very helpful and will answer in a few weeks.

To those of you who don't live in a large city, you've got two choices: you can either call the chemical companies in a nearby large city (although your phone bill will probably be murder) or you'll just have to depend on part III for your chemical needs.

If you need a cover story for any particular chemical, check out the "Dictionary of Old Fashioned Terms and Synonyms" in the front of GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY. This will usually provide one. Or, look the chemical up in THE CONDENSED CHEMICAL DICTIONARY (see "Laboratory Safety" on Page 1030 of THE SURVIVOR) which lists most of the common chemicals and their uses.

This is all well and good, but what about after the crash? You're not going to be able to just walk into Fisher Scientific Company and order up a pound of potassium chlorate, are you?

After the crash, my suggestion would be to go to any one of the chemical companies listed in the phone book and just take what you need. But, beware; do this only

when you feel you have enough manpower to move about and defend yourself in a large city. If you don't like the idea of going into a large city after the crash, try any small town high schools or universities in your area. They both usually have a pretty good supply of chemicals on hand and I don't think anyone else will bother to take them before you do. After all, what use are chemicals to anyone who doesn't know how to use them?

I don't think you're going to want to go all the way back to alchemy to get your chemicals after the crash. It's just too damned difficult and time-consuming. The processes take forever, need constant attention and yield impure chemicals to boot. Also, the methods are downright gross (for example, grinding up red army ants, searching through piles of dung, etc.) so it's best just to forget about alchemy.

PART II - LOCALLY AVAILABLE CHEMICALS

First of all, one thing I want to stress is that you should always read the label of any product that you're planning to buy for chemical content to make sure that the product is, in fact, that chemical. If you buy something and it turns out to be something other than what you wanted, don't come crying to me. It's your own fault.

First, I will give the chemical name of the material I'm talking about. Then, if that name doesn't appear in GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY ("The Dictionary of Old-Fashioned Terms and Synonyms" which begins on Page 2), I will put a name in parentheses that does appear. If I can find a second name for the chemical, I'll put that in too. If I can't find either, I'll put "No GWBC Reference").

All of the chemicals listed below are ones that I have actually seen or bought. There are without a doubt more that I haven't seen. If you know of a source of a particular chemical, write into the letter column of THE SURVIVOR and let others know about it. If everybody does this, we should get almost all of them.

By the way, in this section, "GWBC" means the enlarged edition of GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY.

Acetic Acid - White vinegar is a 5 percent acetic acid solution. Be sure to get white vinegar because the colored kind contains impurities. To make concentrated acetic acid from vinegar, see number 3896 in GWBC (page 249).

Acetone (No GWBC Reference) - I've found this in the drug store. Try there and

if you don't have any luck, try auto parts and paint stores because acetone is used as a paint solvent.

There are a lot of aluminum sources around the house in the form of aluminum foil, aluminum soda and beer cans, etc. but there is a problem in that this kind of aluminum is not pure; It's built on some kind of fibrous base. To see this for yourself, simply melt a hole in an aluminum soda can with a propane torch. There will be a thin web of material that will not melt. This is what I'm talking about.

Something that might work is to cut up a couple of aluminum soda cans and put them into a pipe crucible (see "Lab Equipment for the Amateur Vol. 3, 1036). Then melt the aluminum from the base in a coffee-can blast furnace and pour it off. If you want powdered aluminum, see GWBC (specifically "Granulation" on page 225 and "Powdering by Granulation" NO. 25).

Ascorbic Acid (No GWBC Reference) This is commonly called vitamin C and can be gotten at any health food store. Note: This stuff is easily destroyed by heat and age. Follow the storage directions on the bottle religiously.

Aspirin (No GWBC Reference) Obviously get it at any drug store, but buy the non-brand-name kind and don't buy any that's buffered. That means the aspirin contains chemicals to help keep stomach acid down.

Ammonium Hydroxide (Ammonia, Solution of) - This is just common, household ammonia, but buy the clear kind as opposed to the sudsy kind.

Ammonium Sulphate (Ammonia, Sulphate of) - This is a garden chemical and it's bought in five-pound bags at any garden store.

Boric Acid (Boracic Acid) - This is gotten at any drug store. It's used as an eyewash.

Butane (No GWBC Reference) - This is gotten from either a disposable butane lighter or from butane lighter refill cartridges.

Calcium Carbide (No GWBC Reference) - This is gotten at some sporting goods or hardware stores where it is used to fill carbide lamps.

Calcium Carbonate - It used to be that common blackboard chalk was always made up of calcium carbonate, but not any more (although some still is). The best bets for calcium carbonate are marble, whitening and clam or oyster shells.

Calcium Hydroxide - This is gotten at any garden supply store where it's sold to make soil alkaline. It can also be found at a building supply, hardware or landscaping store.

Calcium Hypochlorite - This can be gotten from a swimming pool store. It's used as a swimming pool chlorinator (HTH is a brand name). It also makes up a couple of non-brand-name long-term toilet bowl cleaners.

Calcium Phosphate - Bones or bonemeal contain about 60 percent calcium phosphate (bonemeal is a fertilizer gotten from any garden store). To increase the percentage of calcium phosphate, put the bone meal or broken bone bits into a pipe crucible and heat a coffee-can furnace for about an hour at full heat. This will drive off the more volatile portions and leave purified, though not absolutely pure, calcium phosphate.

Calcium Sulphate - Plaster of Paris, gotten at any hardware or artist's supply store, is almost pure calcium sulphate.

Carbon (No GWBC Reference) - You can buy charcoal briquettes at any grocery store during the summer months. But, if you need powdered carbon, and you usually do, here are some pretty easy ways to powder charcoal briquettes:

You can buy an old blender from any Goodwill or Salvation Army store. Toss a couple of briquettes in after you've reduced them to the size of peach pits with a hammer. Don't use your household blender to make powdered charcoal because, sooner or later, you'll break a blade and ruin it.

A good, non-mechanical way of powdering charcoal is to tie a few briquettes loosely up in a piece of tough cloth. Then, place a couple of sheets of newspaper on a concrete floor and begin to pound the charcoal, still in the cloth bag, with a hammer. Very fine charcoal powder will sift through the cloth and collect on the newspaper. It should be collected every now and then and stored.

Kurt's article on making gunpowder (page 51 of THE SURVIVOR) has some excellent methods of powdering carbon.

You can sometimes buy ready-made powdered graphite (the same thing as powdered carbon for our intents and purposes) at a feed store or farmer's exchange. Farmers mix it with their seeds as a lubricant when they're using a mechanical seeder.

Carbon Dioxide (Carbonic Acid Gas) This gas can be gotten in the form of dry ice at most beverage places. Look in the yellow pages under "Ice." Or, you can try a welding supply company which usually stocks several types of compressed gasses.

Carbon Tetrachloride (No GWBC Reference) - This is more of an "isn't" than an "is." Carbon tet was taken off the market a while ago because they think it causes cancer. About the only places that

still sell it are chemical supply houses. If you need it for a solvent and not for its chemical properties, then look under "1,1,1-Trichloroethane" later on in this article.

Cellulose (No GWBC Reference) - Cellulose is found in both cotton and wood, so either an old cotton T-shirt or sawdust will serve very well as cellulose. But, for the purest kind, go to a drug store and buy some sterile cotton, which is used for dressing wounds and is sold by the pound.

Citric Acid - This can usually be found in any health-food or drug store.

Copper - This is gotten from copper wire or pennies. If you want copper filings, just open up an appliance cord and cut the little wires inside into small pieces.

Cupric Sulphate (Sulphate of Copper) - This can be found at any drug store. It's used as a germicide. It's also to be found in hardware stores as a fungicide, insecticide, or a root destroyer.

p-Dichlorobenzene or para-Dichlorobenzene (No Reference) - this is one of the two main chemicals that moth balls are usually made of. The other is Naphthalene (qv.).

Diethyl Ether (Ethyl, Oxide of) - When someone says just "ether", this is the chemical they mean. A very impure form of ether (and therefore not for use on humans) is found in spray-type car starting fluids; "Westley's Instant Start" being a brand name.

Ethyl Acetate (Ethyl, Acetate of) - Some fingernail polish removers are nothing but pure ethyl acetate.

Ethyl Acetate (Alcohol) - Almost pure, 195 proof ethyl alcohol can sometimes be gotten at a liquor store. If they don't have that, either buy a bottle of vodka, make your own or distill off the alcohol from cheap wine as on page 45 of THE SURVIVOR.

Of course, you can always look for denatured alcohol at any hardware or paint store.

Ethylene Glycol (No GWBC Reference) - Most brands of anti-freezes are nothing but ethylene glycol and little coloring. But watch out because some brands are methyl alcohol.

Ferrous Sulphate - This is sold at any gardening store under the name "Copperas" as a feed and additive and fertilizer.

Formaldehyde (Formalin) - Drug stores stock this as an antiseptic.

Glucose (No GWBC Reference) - This is another name for cornsyrup or corn sugar. Try a large supermarket.

Glycerine (Glycerol) - Glycerine is sold at any drug store as a skin softener.

Hydrochloric Acid (Muriatic Acid) - This is found at most hardware and swimming

pool stores. It is used for cleaning concrete, bricks and killing algae in swimming pools.

Hydrogen Peroxide - A 3 percent solution is available from any drug store.

Iodine - You might think that you can get pure iodine as the stuff you put on cuts and scrapes, but this is only a weak solution of iodine in alcohol. Pure iodine is actually a grey slightly metallic solid.

Iron - Iron is all around as nails, steel wool, etc. If you want iron filings, try cutting steel wool into tiny pieces with a pair of scissors.

Isopropyl Alcohol (No GWBC Reference) - Any drug store sells a 70 percent solution of this stuff in water.

Lead - Lead is sold in sportman's shops for making bullets and lead sinkers. It's also sold in hardware stores as a plumbing supply.

Linseed Oil - While not really a chemical, linseed oil is called for every now and then in GWBC. It can be gotten at any paint or hardware store.

Magnesium Hydroxide (Milk of Magnesia) - Milk of magnesia is just a suspension of magnesium hydroxide in water with a little gum added to keep the stuff in suspension. You can get milk of magnesia at any drug store or supermarket.

Magnesium Sulphate (Sulphate of Magnesia) - Epsom salts are magnesium sulphate and epsom salts can be found at any supermarket or drug store.

Manganese Dioxide - If you open up a dry cell (not the alkaline kind, just an ordinary flashlight battery), you'll notice a lot of black, icky stuff between the carbon rod and the outer zinc case (more on zinc later). This is mostly manganese dioxide.

To purify it, break open three D-size flashlight batteries and collect the black, pasty stuff described above. Put this in a pint jar and fill it with warm water (distilled, if possible). Slowly stir the jar for two or three minutes, let the suspension settle (it'll take about half an hour) and then pour off the water, taking care not to disturb the black precipitate at the bottom. Repeat this washing once more, then take the purified manganese dioxide out of the jar and put it on a paper towel to dry.

Mercury (Quicksilver) - You can get mercury from old thermometers and mercury switches.

Methyl Alcohol (Methanol) - Some drug stores sell chemically pure methyl alcohol. Also, some anti-freezes are methyl alcohol.

Naptha (No GWBC Reference) - This is a class of some couple thousand compound that someone decided to name "naptha". It's not generally used as a chemical, but as a solvent. Anyway, lighter fluid is

naptha and so is rubber cement thinner along with about a hundred other solvents.

Napthalene (No GWBC Reference) - This is the other common chemical that moth balls are made of. Read the box to be sure of what you're buying.

Nitric Acid - This much sought-after chemical is sometimes used to clean coins and antiques, so you might find it in either a coin or antique shop.

Nitromethane (No GWBC Reference) - Nitromethane mixed with methyl alcohol makes up the fuel used in model race cars and model airplanes. Methyl alcohol boils at 67 degrees C. while nitromethane boils at 101 degrees C. so you should be able to boil off the alcohol as follows:

This must be done outside. Simply pour the model airplane or race car fuel in a glass pot along with a centigrade thermometer and boil. As long as the thermometer reads 70 degrees C. or so, the alcohol is boiling off. When the temperature begins to rise, remove the pan from the heat. It now contains almost pure nitromethane. Warning: Both nitromethane and methyl alcohol are very flammable. See "Laboratory Safety" on page 397 for information on heating flammable chemicals.

Nitrous Oxide (Laughing Gas) - Nitrous oxide can sometimes be found at a welding supply company although I don't know what welders would do with it and they're likely to ask questions.

Nitrous oxide is also the propellant in Rendi-whip and some other pressurized whipped creams.

Oxalic Acid - This is sold at drugstores as a stain remover.

Potassium Chlorate (Chlorate of potassa) - This is gotten from matches

Potassium Chloride (Chloride of Potassium) - This is a common garden chemical and can be found at any garden store or farmer's exchange.

Potassium Nitrate (Nitrate of Potassa) - You can get potassium nitrate from a drugstore for "meat curing," from a garden store as "fertilizer" or "Stump Remover" and from soil as on page 284 of POORMAN'S JAMESBOND VOLUME 2.

Potassium Permanganate (Permanganate of Potassa) - I've seen this in drug stores where it's sold as a disinfectant and also in fish stores where it's used to cure fish diseases.

Propane (No GWBC Reference) - The refill cylinders for propane torches are an excellent source of propane. The diagram shows how to attach a hose to the propane tank. (Illustration 1).

Silicon Dioxide (Silicious Sand) - Clean, white beach sand is almost pure silicon dioxide. So is window glass.

Silver - If you need silver, you'll have to melt down the family jewelry. Coins minted before 1964 also had a lot of silver in them, but they're as rare as hen's teeth nowadays.

Sodium Bicarbonate - This is bought at any supermarket as baking soda.

Sodium Bisulphate - This is also called "soda acid sulphate" and several toilet bowl cleaners contain this as their main ingredient. Sani-Flush is an example. Sodium Bisulphate is also found in pool stores where it's sold to acidify swimming pools.

Sodium Carbonate - This is also from your local swimming pool store. Sodium Carbonate is sold to make pools more alkaline. It's also sold in supermarkets as "Washing Soda."

Sodium Chlorate (Chlorate of Soda) This is made from solidox as in "Sodium Chlorate from Solidox" on page 564 of THE SURVIVOR.

Sodium Chloride - This common table salt and can be found in any supermarket.

Sodium Hydroxide - This is common lye and it can also be found in any supermarket.

Sodium Hypochlorite (No GWBC Reference) - Liquid chlorine bleach is a 5.25 percent solution of sodium hypochlorite. Pool bleach is even stronger at 10 percent.

To get the stuff out of solution, you have to evaporate all of the water off. Don't get the bright idea of boiling the water away because sodium hypochlorite is decomposed by that much heat. Evaporate in a plastic dishpan, etc., also, add a little lye before you evaporate the solution. This will help to stabilize the solid sodium hypochlorite.

Sodium Nitrate - This is sold at most garden stores as a fertilizer.

Sucrose (No GWBC Reference) - this is just common table sugar and you can find it in any supermarket.

Sulphur - Garden sulphur is fairly pure and I've seen it at Sears and several garden stores. You can get very pure sulphur at any drug store where it's sold as a laxative.

Sulphuric Acid - Battery acid is a very pure, but dilute solution of sulphuric acid. To concentrate it, pour some into an enameled or glass pot and boil until dense, white fumes appear (Don't breathe them!). The heavy, oily-looking liquid left in the pan is concentrated sulphuric acid.

1,1,1-Trichloroethane (No GWBC Reference) - Since carbon tetrachloride has been taken off the market, some enterprising young fellow is marketing this chemical as "Replacement Carbon Tetrachloride." You should be able to find it in any large hardware or paint store.

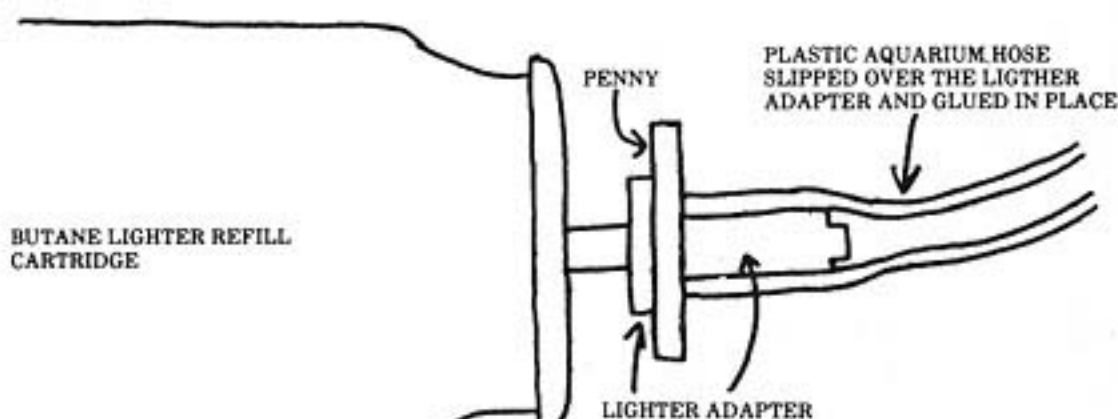
Urea - This Chemical is made from

urine. To extract it, see page 272, number 4323 of GWBC.

An easier method of extracting the urea is to boil the urine until it's almost, repeat almost, dry. The solid left in the pan is a mixture of urea and salt. Anyway, lay it on a paper towel to dry.

When the solid is dry, place it in a glass with about a cup of alcohol and mix it up. The alcohol will dissolve the urea and leave the salt behind. To retrieve the urea, just distill off the alcohol.

A SOURCE OF BUTANE



Wax (No GWBC Reference) - Paraffine wax is sold at most supermarkets for canning purposes. It's also sold in larger quantities at hobby shops for candle making.

Zinc - Remember a while ago when I said "more on zinc later?" Well, this is later.

When you were ripping apart that dry cell to get at the manganese dioxide, you probably didn't pay any attention to the metal case that the black stuff was contained in. Well, that case is made of zinc.

It's going to be covered with battery paste when you finally succeed in tearing it away from the battery, so clean the zinc by holding a piece of it in a pair of pliers and taking a fine wire wheel to it. The thing labelled "LIGHTER ADAPTER" is the thing that comes with most butane refill cartridges. It's a plastic thing that allows the refill cartridge to be used with several different brands of lighters. The penny is drilled so that it will slide over the long nozzle but not over the ridge at the end. To release the butane, just pull on the penny.

PART III - THE CARE AND TREATMENT OF CHEMICALS

So, let's assume that you've found a company and are now ready to begin stockpiling.

First of all, most chemicals gotten from a chemical house are plainly marked as to storage conditions, shelf life, things

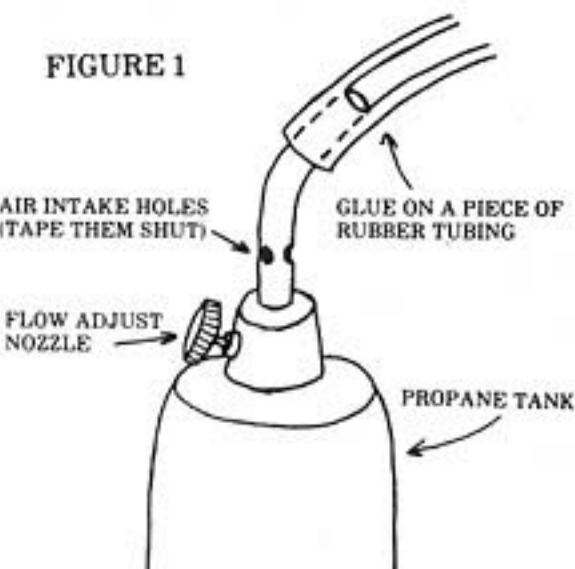
to watch for, etc. so you don't need to worry too much about finding out the storage characteristics of specific chemicals.

A good chemical storage set-up should be away from everything (for obvious reasons) and should be at 72 degrees F. or thereabouts. There should be good ventilation and the chemicals should first be arranged by types, then shelved alphabetically. In other words, put all the

oxidizers in one section as far away as possible from anything they might react with, put all the solvents in another group, and so on. Then, arrange the members of each group alphabetically.

Of course, all containers should be labelled plainly and permanently and after using a chemical (especially a liquid), make sure that the outside of the bottle is free from any residual material. Also, make sure that all of the chemicals

GETTING THE PROPANE FROM A PROPANE TORCH



you're planning to use in a reaction don't react with their reaction vessels (For example, don't use hydrofluoric acid with glass, nitric acid with copper, etc.) You should also try to avoid storing chemicals

too far above eye level and, of course, there should be no smoking in either your storage area or the lab itself.

Try to make as much an effort as possible not to store chemicals in your actual lab area. In case of a fire in your lab, all of those chemicals adding to it could mean the difference between living and dying. I know it seems like you'll be forever running back and forth fetching

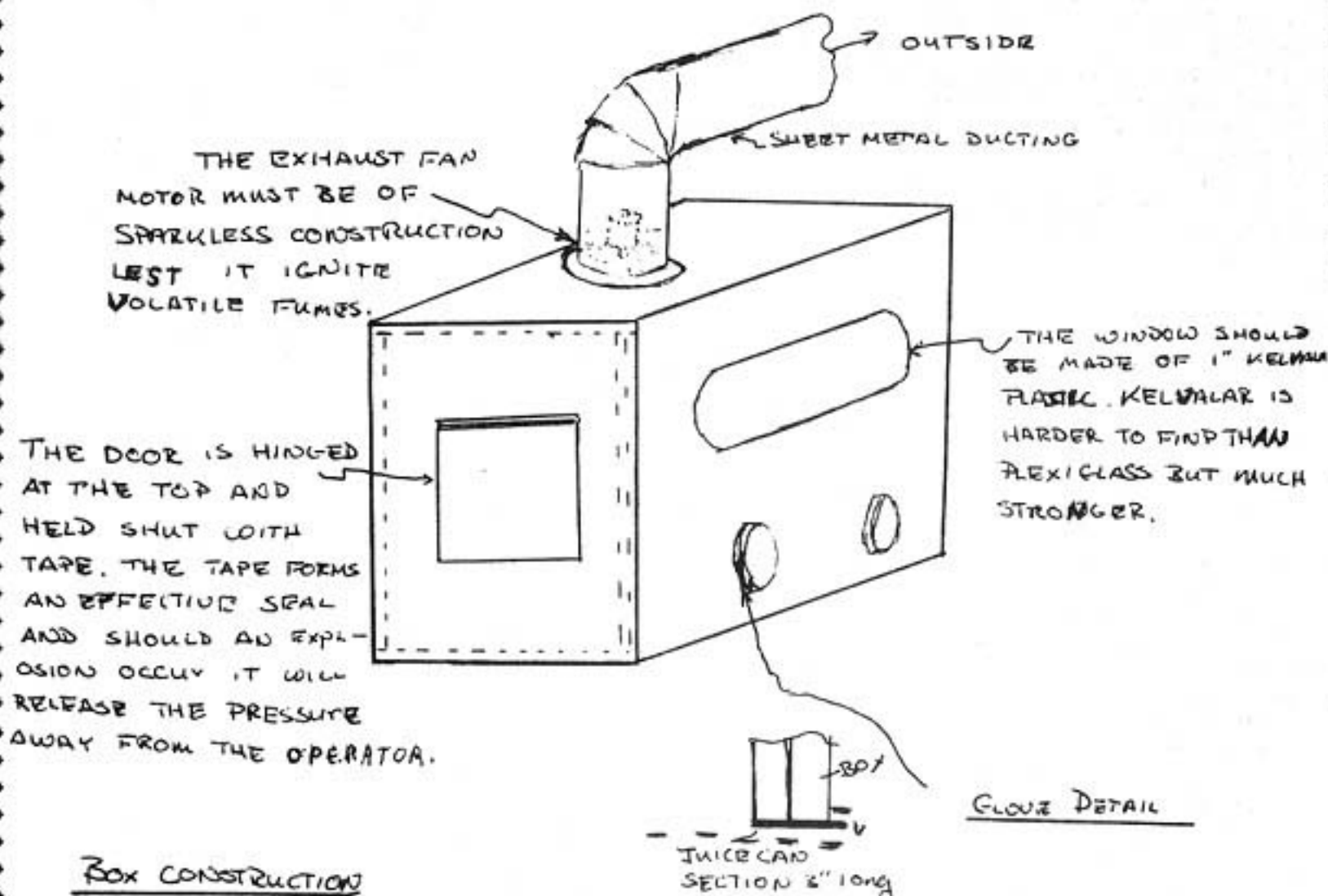
chemicals, but it's not that bad really.

Always remember that lab chemicals are not household food products. By this I mean that if you originally buy a box of baking soda and put it in your lab as sodium bicarbonate, it is no longer baking soda and should not be treated as such. This does two good things: It prevents you from accidentally sprinkling sodium cyanide on your egg salad sandwich

instead of the sodium chloride you thought it was. It also prevents you from using chemical company products as household food products. At first thought, this may not seem like too much of a sin but, while chemically pure sodium chloride may be 999 parts in a thousand pure, what is that other part? It could be arsenic trichloride for all you know. In short, don't eat your chemicals.

A SEALED GLOVE BOX

TO PROTECT THE CHEMIST FROM FIRE AND EXPLOSION



THE DOOR IS HINGED AT THE TOP AND HELD SHUT WITH TAPE. THE TAPE FORMS AN EFFECTIVE SEAL AND SHOULD AN EXPLOSION OCCUR IT WILL RELEASE THE PRESSURE AWAY FROM THE OPERATOR.

Box Construction

THE BOX ITSELF IS CONSTRUCTED OF ONE INCH PLYWOOD, WITH A DOUBLE LAMINATE FOR THE FRONT, FOR MORE PROTECTION AND EASY WINDOW MOUNTING. IF YOU PLAN TO EXPERIMENT WITH FULMINATE OR AZIDE COMPOUNDS THE FRONT SHOULD BE LINED WITH $\frac{1}{4}$ BOILER PLATE STEEL AND HAND PROTECTION CONSIDERED. THE BOX IS FINISHED WITH EPOXY, THIS FINISH WILL RESIST MOST CHEMICALS OR SOLVENTS.

THE GLOVES SHOULD BE HEAVY NEOPRENE RUBBER AND COTTON LINED. THEY WILL RESIST ALL ACIDS, ALKALIS AND MOST SOLVENTS. THEY ARE AVAILABLE THROUGH INDUSTRIAL CLEANING SUPPLY STORES.

by ALLEN D. HOFFMANN

Low-Cost CRUCIBLES

for melting cast iron, brass, bronze, copper, aluminum, and other metals



A few metal molds and crucibles made in them. The mixed fire clay and fire brick are rammed heavily into the mold, then ejected, dried, and baked

By LEO G. HALL

(Popular Science 1938)

SINCE even the best crucibles do not outlast many heats, the home foundryman or furnace experimenter will find it profitable to make his own.

One method requires a mold, made in

four pieces as shown in the drawing below. The outer mold and the compression plug should preferably be made of cast iron or steel. The core mold can be made of softer metal or even wood.

Fire-clay crucibles are satisfactory for melting brass, bronze, copper, cast iron, type metal, white metal, babbitt,

aluminum, and the like, but not steel and other very high temperature alloys or glass. The fire clay can be bought for a few cents a pound at brickyards or furnace shops. To avoid excessive shrinkage, it is necessary to dilute the clay with broken fire brick, pounded up with a hammer so that it will pass through a piece of fine window screen. Mix 1 lb. of dry fire clay thoroughly with 1½ lb. of the fire brick and add water very slowly until the mixture is barely moist and crumbly, like fresh bread. If more water than this is used, the crucible will stick to the mold.

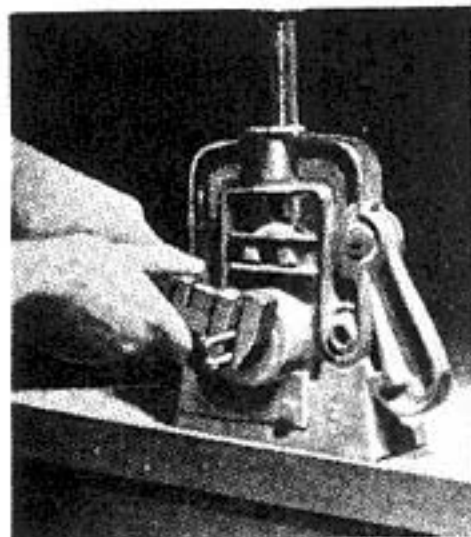
The mixture is inserted a little at a time into the hole at the top of the outer mold, and rammed down thoroughly all around the inner mold with an old half-round file. When the mold is filled nearly to the top, insert the steel compression

plug and drive it in with a heavy hammer until flush with the top of the outer mold. Then turn the mold upside down, remove the filler ring, and hammer in the interior mold until its base is flush with the end of the outer mold. This brings the clay at both ends to about equal density.

The inner mold must be removed first. To do this, clamp the mold, with crucible inside, in a pipe vise, insert small bolts or pins into the holes in the base of the inner mold, grip them with a wrench, and twist. When the inner mold has been removed, the outer mold is stood on end and the compression plug gently tapped with a hammer to loosen the crucible. Dry the crucible for twenty-four hours on top of the house furnace or for a few hours in a baking oven.

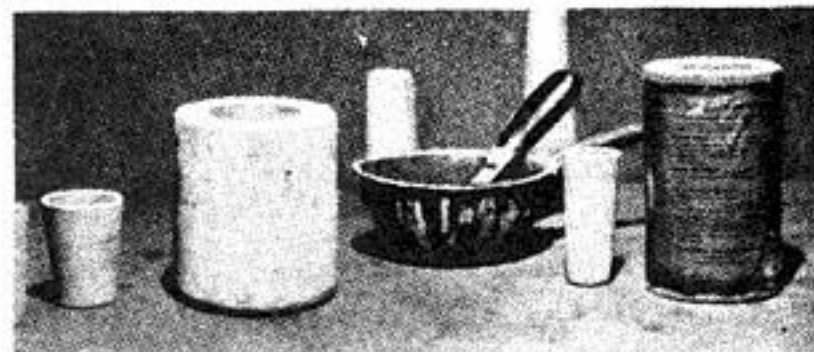
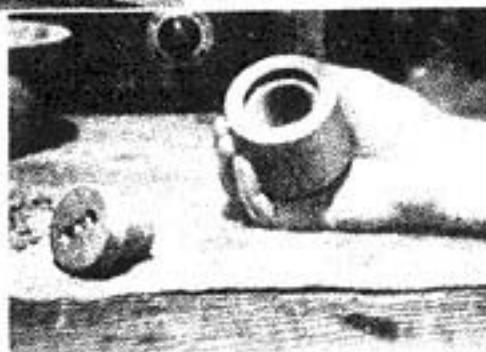
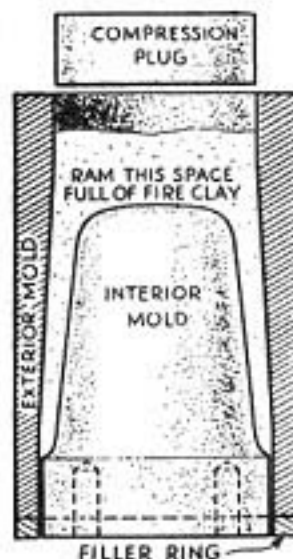
THE crucible should next be baked to about 1,800 degrees F. This may be done in an electric furnace or in a gas or

The four parts of a mold are shown in sketch at left. Note filler ring



The first step in taking out the crucible is to twist out the inner mold by using two pins

Right, the inner mold is removed, and the crucible top can be seen in the outer mold



Molds of a second type, made from plaster of Paris, and the resulting crucibles



The dry plaster mold is filled with a creamy mixture of clay. After a layer has been deposited on the inner surface, the residue is poured out

gasoline blast furnace. Bring the temperature up very slowly and be sure that the crucible is heated uniformly on all sides. The writer frequently bakes crucibles up to temperature, then—and not before—adds the metals.

Pressure-molded crucibles are always more or less porous. If a denser surface is desired, pure fire clay mixed to a cream with water may be painted on the surface and the crucible rebaked. Another method is to dip the crucibles in a strong, boiling solution of aluminum sulphate or epsom salt after being baked, then slowly dry and slowly rebake them. This may be repeated as many times as desired. Good ventilation must be provided if this process is used because of acid fumes.

When melting metals in a gas- or oil-fired furnace, a porous crucible is apt to result in the formation of a good deal of dross, as the furnace gases penetrate the crucible wall and attack the



Crucibles are made at trifling cost from fire clay and finely powdered fire brick

metal. Porosity does comparatively little damage, however, in the electric furnace. To reduce dross formation, crucible covers should be used. They may be made of the same material as the crucible and by the same general methods.

ANOTHER method of making the crucibles is to cast them. This gives a much denser product, but more skill is required. Only a single outer mold of plaster of Paris or Portland cement is needed. If made of plaster of Paris, it is well to dissolve a little alum or borax in the water so the plaster will not set too quickly. The plaster (or Portland cement) is then poured slowly into the water, which is stirred continuously until the mixture reaches a creamy consistency. Stir until all lumps disappear and all air bubbles are worked out. To insure this, it is well to strain the mixture through a piece of window screen before it is used.

Pour the mixture into a porous con-

ANTI-ABORTIONISTS—RIGHT TO LIFERS OR GUARANTORS OF DEATH

by Kurt Saxon

The abortion issue is no big deal as far as overall survival is concerned. However, Anti-abortionists are in a futile crusade which places an undue emphasis on bringing more people into an already over-crowded world. Furthermore, their misplaced idealism can only make matters worse for mothers who want to limit the size of their families and causes additional privation to our poorest classes.

The Catholic Church has always fought birth-control and is in the forefront of the battle against abortion. Their reasons are traditional and they are stuck with them. But for non-Catholics to become militant in such a cause is just another example of the irrationality pervading our culture.

The most worrisome part of this issue, to me, is that our Conservative element has been sucked into this silliness. The Conservative is traditionally against welfarism and all influences toward a greater number of parasites in our society. Yet, more Conservatives are joining the ranks of the Anti-abortion fanatics.

This confuses me and I have asked many of my Conservative friends how this insanity crept into the Right-wing movement; if such a movement really exists anymore. None could tell me how the issue got started in their ranks. It seems, however, that the religious elements borrowed the issue from the Catholics and sold it to the predominantly racist Conservatives, somehow in the belief that abortion was decimating the ranks of the white population, which they believe is being outbred by minorities.

Conservatives seem to envision happy, healthy, white children, playing peacefully in good homes except for vain white women who want to retain their figures or want to work, rather than take care of children. There are such, of course, but the fact is, the average abortee is indeed saved from a miserable, precarious existence, neglected, abused and often brutalized by unwilling, poverty-stricken, ignorant parents. Most women wanting abortions are unwed, poor, drug addicts and/or non-white.

Former Los Angeles Police Chief Ed Davis, running for the governorship of California, was quoted as saying that he was against state-funded abortions because they were racist. He contended that most abortees are blacks or Latinos. I disagree with his stand against state-funded abortions, but he's in a position to know the statistics. White Conservatives should consider this before campaigning against state-funded abortions.

Of course, the non-Conservative Anti-abortionists are against all abortions but their main thrust is against state-funding of such. An abortion costs the state about \$150.00. Statistics show, however, that if the abortion is stopped, the taxpayer will pay many thousands of dollars rearing the unwanted child. Also, the environment such unwanted children are reared in will put a large proportion of them into the streets as murderous delinquents, leading to great property damage, loss of valuable lives through murder, leading to long and expensive prison terms.

Whether state-funded or paid for by the mother, abortion is usually a kindness and no loss to society or the race. Regardless of the pregnant woman's reason for not wanting the child, the fact is that an unwanted child is an automatically damaged child. Even in middle-class environments, the unwanted child is emotionally abused and deprived of the love and attention a child must have to develop into a normal, outgoing, productive member of society. The fact that white, middle-class delinquents are just as vicious and destructive as ghetto delinquents cannot be denied. They were unwanted before birth and ought to have been aborted. (See pages 64 and 84 of Volume 1).

Anti-abortionists shrug all such arguments aside with the reply that abortion is the murder of a human being.



The moist, crumbly mixture is forced into the mold with a discarded half-round file

tainer such as a cardboard box. A metal container will not do. A very smooth metal or wooden pattern turned to the shape of the outside of the crucible is now dipped to the desired depth into the mixture and clamped securely. The pattern should be turned about one tenth larger than the finished size of the crucible. If a wood pattern is used, it must be soaked for several hours in water before use.

After the mold has set but before it is dry, the pattern is withdrawn. The mold should be set aside to harden a few days before use.

The fire brick must be screened finer than for the pressure-molded article. A screen of 60 or 80 meshes to the inch is about right. About 1 lb. ground fire brick and 2 lb. fire clay are stirred into water until a creamy consistency is reached, using the same precautions required for mixing plaster. Better results will be obtained if the wetted clay (or slip) is left to stand a few days before being used, then stirred up again.

ENOUGH of the slip is poured into the dry mold to fill the latter. As the plaster absorbs water from the clay, a layer of stiff clay is deposited on the surface of the mold. When this layer has reached about $\frac{3}{16}$ or $\frac{1}{4}$ in. in depth, the remaining clay slip is poured out, and the mold with the layer of adhering clay is set aside to dry. As the clay dries, it shrinks and breaks away from the mold in the form of a solid cup, which can be removed. Irregularities in the inside surface may be smoothed off with a suitable tool or sandpaper after the crucible is partly dry, but before it is baked.

A little glucose obtained from a cany manufacturer, if dissolved in the water, will make clays more sticky and improve results with some of the poorer clays.

The crucible, once it has come loose from the mold, will continue to shrink. The more slowly it is dried and baked, the stronger and denser it will be. It

Exodus 21:22-23 says:

22 If men strive, and hurt a woman with child, so that her fruit depart from her, and yet no mischief follow: he shall be surely punished, according as the woman's husband will lay upon him; and he shall pay as the judges determine.

23 And if any mischief follow, then thou shalt give life for life, . . .

In short, if a man causes a woman to miscarry and lose her child, he is simply fined. If "mischief" follows, which could only mean the death of the woman, he dies.

So the writer of Exodus obviously didn't consider the unborn fetus to be a living being with a soul, regardless of its potential. Otherwise, the man causing the miscarriage would have forfeited his life. If the Bible was inspired by the Creator, then the Creator doesn't consider the unborn an entity but only a potential shell or vehicle for an entity.

My editorial on page 64, Vol. 1, of THE SURVIVOR showing diagrams from Psychology Today proves a child is not human before its brain cells are properly linked up. Before then, humanity, the level of consciousness and awareness which differentiates us from the lower animals is impossible.

So neither the Bible nor science supports the idea that the unborn are "human," despite their potential. So to force an ignorant, impoverished and usually defective woman to complete an unwanted pregnancy is not only cruel and inhumane, but an injury to the species.

Then there is the question, "What is a human being?" A homo sapien, in my opinion, is only human after the brain has developed to the point where he is a potentially functional homo sapien. Unwanted children seldom develop qualities which differentiate them from the lower animals.

In the philosophical sense, I can see no rational objection to abortion. If you are an Athiest, you can but see a fetus as a potential biological machine. Its abortion would only be the same as taking an uneconomical car off the assembly line and junking it.

If you are a Reincarnationist, as I am, you believe that the unit of concious energy in the aborted fetus will simply drift around until it finds another female who has conceived, and hopefully, a female better qualified to be a good mother.

Modern Christians teach that when a baby dies it automatically goes to Heaven. Logic shows that the unwanted child has so little chance for a good Christian upbringing that its abortion would guarantee Paradise whereas its birth into an environment of chaos and hatred would practically guarantee its ending up in Hell.

An element in the Anti-abortion mentality seems to be a hatred of women, even by other women. An unwed mother must pay for her mistake. A vain woman deserves to lose her figure. A career woman should not escape the drudgery of the sanctimonious brood sow. For after all, was not woman decreed by her creator to be an incubator? These attitudes are hypocritical and the expressed concern for the unwanted child is just crocodile tears.

Abortion finally became legalized mainly because, throughout the ages, women who wanted to terminate their pregnancies have resorted to drastic and often fatal methods of abortion.

I quote from PRACTICAL BIRTH CONTROL METHODS, by Norman E. Hines, Ph.D 1938, (page 151) "Yet our savage ancestors, the anthropologists tell us, regularly aborted themselves. So did the ancient Egyptians, Hebrews, Greeks, Romans, the early Christians, the early Chinese, and others from that day to this. That is what makes the social and legal control of abortion so difficult—the fact that it is an entrenched habit centuries old. The first known medical recipe for abortion still extant in writing dates from 2737-2696 B.C. in China, more than forty-six centuries ago. If it is that old in writing, how old is the practice?

"Savages jumped on the abdomen of pregnant women or strung them up to a tree by a band about the waist. They used sticks as uterine probes but more often relied on magic, even as their contemporary descendants do. Naturally

should be held at baking temperature for a couple of hours before any metal is put in it; and preferably should not be used for melting until it has been slowly cooled to room temperature after the baking heat.

Three or four crucibles can easily be cast from one mold before it has to be set aside to dry, but the casting operation takes longer for each succeeding crucible, as the mold becomes wetter. The mold should preferably be dried at room temperature, not heated, otherwise water is absorbed from the clay too rapidly.

Needless to say, one or both of the processes described can be used for making muffles, tubes, cupels, and many other useful clay articles, as well as crucibles. By splitting the outer mold into two or three parts, the necessity for a taper is eliminated, and more complicated shapes can be molded.

CHEMICALS FORM QUEER UNDERWATER GARDEN

Popular Science 1933

AMONG the many attractive things that can be made by the amateur chemist, the chemical garden is one of the most unusual. It can be "grown" in a bottle, vial, glass vase, fish bowl, or other transparent receptacle. When the proper chemical is introduced into the liquid, a small treelet will shoot up.

Fill the glass receptacle about three fourths full of a mixture of one part of water glass (silicate of soda solution) to three parts of water, thus making a twenty-five percent solution. Now drop a small crystal of one of the following salts in the liquid: blue vitriol (copper sulphate) for blue trees; potassium dichromate or, as

Strange tree-like forms are "grown" by dropping certain salts into a thin solution of sodium silicate



an alternative, chloride of iron, for orange trees; potassium permanganate for purple; nickel sulphate for green; and lead acetate or silver nitrate for white. These salts are usually found in the amateur's outfit, and they are easily obtained at a

the risks were great, the fatalities high. But that has never been a deterrent. The will to control fertility has been too persistent."

Increasingly, back-alley abortion mills sprang up, killing thousands of impoverished women. Wealthy women have nearly always had access to doctors who would give illegal abortions for high fees. If they couldn't find such a doctor here, they would go to certain European countries where abortions were legal.

If state funded abortions stop altogether, the back-alley abortion mills will go back into business. It should also be apparent to any Anti-abortionist that since abortion here has been legal for years, hundreds of thousands of hospital workers have been trained to assist in legal and safe abortions. So abortions, although unrecorded, would become even more common, since the pregnant woman would receive no counseling against the abortion, as she is now by many doctors who perform abortions reluctantly.

My strongest gripe against religious Anti-abortionists is their making the issue a moral one and extending it to those outside their own religious faiths. I have no objection to a minister preaching against abortion to the women of his congregation. But to impose his views on women not of his faith is not only meddling, but non-scriptural.

There is no mention of abortion in the Bible. The nearest thing to it is in Exodus 21:22 where if two men are fighting and a pregnant woman gets in the way and the man fighting her husband hits her and causes her to miscarry, her husband can sue for damages.

Actually, the Bible is the last book to refer to in defense of children. Biblical characters were notorious for slaughtering children of other ethnic groups and religions.

In 2nd Kings 2:23, 24 Elisha the prophet was teased about his baldness by a mob of little children. He cursed them in the name of the Lord and two she bears came out of the woods and "tare forty and two children of them".

In Exodus 11:5 and 12:29, 30 Jehovah killed all the firstborn of the Egyptians because the Pharaoh balked at releasing the Israelites. The Pharaoh was the offender, but what were Egyptian children to Jehovah?

In 2nd Samuel 2:13-18 David's child by Bathsheba was killed by the Lord because of David's transgression. The child was blameless.

Then there is the infamous record of Moses' treatment of the Midianites. Now, the Midianites were not an inferior race, at least, in comparison with the Israelites. Midian was a son of Abraham. Moses married a Midianite, Zipporah and had two sons by her, Gershom and Eliezer. Ex. 18:1-4. Jethro, Moses' Midianite father-in-law, and a priest, believed in Moses' god and was his mentor and possibly, unwittingly, the greatest influence of his life. You can see this by reading the whole chapter of Ex. 18. Yet, Moses wiped the Midianites off the face of the Earth, as recorded in the 31st chapter of Numbers.

When the Israelites left Egypt, Moses wanted them to immediately attack and conquer Canaan. In Numbers 13:1,2 Moses sends 12 spies to judge the strength of the enemy. Ten of the spies returned saying, in verses 32,33 and chapter 14:1-3 that the Canaanites were too numerous and strong. Ten of the spies died of plague, supposedly because of their pessimism. Num. 14:28-38. Only Joshua and Caleb were spared, since they said it could be done.

It is more likely that the spies who died went further into Canaan and contracted diseases for which they had no immunity. Joshua and Caleb might have had natural immunity, but it is more likely that they hung back and were not exposed. Had they actually gone deep into the territory they too would have seen the impossibility of success against the Canaanites. After all, it is not to be supposed that the Israelites, under Egyptian servitude for centuries, were a match for the warlike Canaanites. The ten spies were simply giving a realistic appraisal of the actual situation.

Because of this rational skepticism, Moses was angered and condemned the people, in the name of the Lord, to wander in the wilderness for 40 years. The unstated reason for this was to let those without military potential (all those

druggist's.

Watch the crystal for a moment; if it starts to grow, all right. If it doesn't, add a very small amount of pure water glass to make the solution stronger. When the first crystal has grown to a fair size (from $\frac{1}{2}$ to $\frac{3}{4}$ in.), drop crystals of different colors over the bottom of the receptacle.

After the trees have stopped growing, carefully siphon off the remaining liquid. The glass may then be filled with water, which reveals the colors of the trees clearly. However, if the garden is to be set in a place where it may receive a good deal of jostling, it is best to prepare, by cooking, a heavy gelatin pudding. Take care to keep it clear and transparent. Pour this in around the formations instead of the water and allow it to set until the gelatin is firm.

Several photographs of the author's chemical garden have been taken, but while they show the general shape and size of the trees, they convey no idea of the colorful effect—green and greenish-blue trees grown around a group of shells that are red and orange in color.

The chemist may vary the design by placing a small model of a galleon or pirate ship or a tiny treasure chest on the bottom of the bowl, for the garden resembles sea plants.—L. L. HYLER.



GLOBE STORES LIGHT FROM ELECTRIC BULB

Popular Science 1933

Storing light in a globe was a feat recently demonstrated by Ethan I. Dodds, America's most prolific inventor, whose collection of more than 2,000 patents was exceeded only by those of the late Thomas A. Edison. The evacuated interior of Dodds' magic globe, which is covered by twelve of his U. S. patents, is coated with a mixture of phosphorescent chemicals. When an electric bulb is held in an aperture and flashed on momentarily, the lamp

over 20 years of age) die in the wilderness leaving only the young and their unsophisticated offspring to finally return. They would then be toughened and ignorant and, hopefully, able to conquer the land.

But even after 40 years of isolation from civilization, the Israelites, instead of fighting, went over to the inhabitants of Moab, who were Midianites, and their god, Baal-Peor and Moses nearly lost his cause right there. Num 25:1-3. If you read the books of Exodus and Numbers, you will see that the Israelites had no use for Moses or his god. When Moses was on Mount Sinai, Aaron, his own brother and right-hand man, made a golden calf, which the Israelites worshipped in preference to Jehovah. Ex. 32:1-6.

In Moab Moses, again in the name of the Lord, killed all the Israelites who had gone over to the god, Baal-Peor. Num. 25:4,5. Even though the ones who had gone over were murdered, a plague broke out and killed 24,000 more Israelites. Verse 9.

Moses was a shrewd politician and used the plague to his greatest advantage. Plagues are caused by invisible microbes, viruses, bacteria, etc. and the primitives of that day were easily persuaded that they were sent by angry gods.

Actually, the Israelites were especially susceptible to diseases. First the ten spies, freed from Egypt and having built up immunity to their diseases, died on contact with foreigners with other diseases.

Then, after 40 years in the wilderness, away from civilizations, the wilderness-born Israelites were even more susceptible to disease than were their parents.

The Spanish Conquistadores and their priests killed far more Indians by their diseases than by force of arms. North American Indian tribes were decimated by such European childhood diseases as measles, mumps, chickenpox, whooping cough, etc. More of Napoleon's troops in Russia died of disease than from combat. In the early part of this century, whole tribes of Eskimos were wiped out by the common cold, given to them by missionaries. Tourists going to Mexico and drinking the water usually come down with the trots, because of bacteria most Mexicans are immune to.

After the plague, Moses had the upper hand and so in the 31st chapter of Numbers, the Israelites attacked and conquered the Midianites. All the adult males were slaughtered. When the captains returned from the battle, bringing the women and children, Moses chewed them out. Num. 14-18. "And Moses said unto them, 'Have you saved all the women alive? Behold these caused the children of Israel, through the council of Balaam to commit trespass against the Lord in the matter of Peor, and there was a plague among the congregation of the Lord. Now therefore kill every male among the little ones and kill every woman that hath known man by lying with him. But all the women children that have not known a man by lying with him, keep alive for yourselves.'"

The extermination of every male Midianite and the non-virgins, many who might have been pregnant with male fetuses, wiped out the Midianites as an ethnic group. This was genocide, pure and simple.

Further, the prey, including 32,000 little girls, were divided between the warriors and the non-combatants. Verse 27. Verse 40 tells of the tribute to the Lord which was 32 little girls. Reading to verse 47, the same number was taken from the congregation's share and given to the Levites to sacrifice. So 64 little girls were butchered and given to their god as a heave offering. (Scribner's Dictionary of the Bible says of the heave offering, Vol. 4, page 38, "—but according to most moderns, heaving was not an act of worship, but only the preliminary act of detaching a portion from the rest of the carcass for the consecration.")

Numbers 25:16-18 shows that Moses, supposedly under orders from his god, had intended to exterminate the Midianites all along. In fact, if you read the books of Exodus, Numbers, Deuteronomy and Joshua, it will be clear to you that Moses aimed at the total extermination of every race and ethnic group in Canaan. Specific verses are Num. 21:35, Deut. 2:30-34, 3:3-6, 7:2,3 and 16, 20:13-17 and Joshua 6:21, 8:25,26.

glows with a soft, even light for two hours. The bottled light, Dodds says, is suitable for use in mines and in industrial buildings, where a night watchman making his rounds, could recharge each globe with a flick of his flashlight.

LUMINOUS DECORATIONS

Luminous lamp globes, as described in the article here, is only one application of luminous paint. See Page 143 for how to make luminous paint. You can probably buy it in your local paint store.

For a child's room you can cut out stars and such, paint them and paste them on the ceiling. Nursery rhyme characters can also be used for the ceiling and walls. Then, when the lights are turned out the child can see the glowing figures and won't need a night light.

For auxiliary lighting around the home, panels, as decorations or plain luminous surfaces can be activated to make a pretty glow in other rooms. Also, a light timer can be devised to flash a bright light on the luminous surfaces at intervals of several minutes, for just a few seconds. This could provide lighting, in many situations, which would save electricity. Luminous paste-ons could be made to sell and could be profitable.

There are three different luminous shades; yellowish, green and blue, so the designs can be colorful as well as luminating.

Cure for Sting of Wasp or Bee.—A little ammonia applied to the puncture will speedily relieve the pain, and so will the juice of an onion obtained by cutting an onion in half and rubbing the cut part over the part affected. It is necessary, however, to be very careful in any attempt upon a wasp, for its sting, like that of the bee, causes much pain and frequently induces considerable swelling. In case of being stung, get the blue-bag from the laundry, and rub it well into the wound as soon as possible. Later in the season, it is customary to hang vessels of beer, or water and sugar, in the fruit-trees, to entice them to drown themselves. A wasp in a window may be killed almost instantaneously by the application of a little sweet oil on the tip of a feather.

To prevent the Smoking of a Lamp.—Soak the wick in strong vinegar, and dry it well before you use it; the flame will then burn clear and bright.

I watched the TV series, HOLOCAUST and read Gerald Green's article on it in the April 15-21 issue of TV GUIDE. In it he says, "the destruction of Europe's Jews by the Nazis, a mass crime unparalleled in human history." Green obviously considers himself a Jew. So he is either a liar or is woefully ignorant of the history of the people he identifies with.

Christians might believe that Jesus brought a new order, free from racial hatred and benign to children. Matthew 10:5,6 has Jesus saying to his 12 apostles, as he sent them out to preach, "Go not into any city of the Gentiles, and into any city of the Samaritans enter ye not. But rather to the lost sheep of the house of Israel."

Mark 7:24-29 tells of a Syrophenician Greek woman appealing to Jesus to heal her daughter. Syrophenician means she was a native of Syria in the state, or province, of Phoenicia and as a Greek, she was descended from Alexander's colonists planted around Tyre and Sidon 300 years before. So she spoke the language and was a citizen and the only thing that made her stand out as a Greek was that she was white among the brown Syrians. (Jacob was a Syrian, as shown in Deut. 26:5, and therefore brown, as were the Israelites, Jesus and the Judeans, as are the Syrians and native Palestinians and non-European Israelis of today.)

When the white woman asked Jesus to heal her daughter, Jesus replied, Mark 7:27, "Let the children (of Israel) first be filled: for it is not meet to take the children's bread and cast it unto the dogs." That was his opinion of white people. But the Greek woman abased herself before him saying in verse 28, "Yes, Lord, yet the dogs under the table eat of the children's crumbs." This groveling by the desperate mother so pleased him that he pronounced her child healed. I don't believe that story but it does express Jesus' followers' attitude toward whites.

It might be argued that in Matthew 8:5-13 Jesus healed the servant of a Centurian, another white. Of course, the Centurian was a man and a Roman command officer in a dominant position over the Judeans. It was now Jesus' turn to grovel. Had he refused, or worse, referred to the Centurian as a dog, zap, religious whites would be worshipping Odin today.

After his crucifixion, Mark 16:15 has Jesus saying to his disciples, "Go ye into all the world and preach the gospel to every creature." This, and most other references to the conversion of non-Israelites was after his physical death. Either his physical death completely changed his previously held attitudes of contempt for all non-Israelites, or his followers, having been generally rejected by the Judeans and having lost their leader, wanted to keep their game going and so were willing to seek foreign converts to stay in business.

So the Bible, even the New Testament, holds no arguments in favor of preserving the children of any but those belonging to the congregation. Therefore, Anti-abortionists using Christian morality to back up their arguments against the abortions of others than their own faiths are either ignorant of the Bible or are simply hypocrites. □

Victim defiant, robber calls cops

Chicago Tribune, Sunday, July 9, 1978

IONIA, Mich. (UPI)—A would-be robber whose victim refused to hand over the money, called police and asked them to force the victim to cooperate. Police locked him up.

Police said Joe Basinger, a gas station attendant in this western Michigan town, was on duty late Friday when Larry Tate, 29, of Ionia, drove up and tried to rob him. Police said Tate told Basinger he had a gun in his pocket.

Basinger refused to cooperate, police said, and Tate

threatened to call police to force Basinger to cooperate.

The attendant dared Tate to follow through on the threat and offered free use of the phone, police said.

TATE MADE the call and police arrived moments later and arrested him.

"I would think we would chalk it up to his being a little bit stupid," said police spokesman Vi Troxel Saturday. "He probably just got utterly confused when things did not go the way he wanted."

MAKING MOCCASINS THAT REALLY FIT

From Popular Science 1937 By Maurice H. Decker

THIS Objibwa type, two-piece moccasin fits like a shoe and is splendid for still hunting and hiking, for camp use, for canoeing and yachting, and to wear as a house slipper.

Materials: 1 pc. heavy oil-tan leather 12 by 22 in., 3 yd. $\frac{1}{8}$ -in. lacing, and 1 pair 3/16-in. thongs for ties. The cost is from \$1.25 to \$1.50. Any dealer in leather can supply regular moccasin stock and laces.

Lay off the toe and bottom patterns on cardboard, cut to shape, and punch out the holes. To obtain a right and a left for each piece, merely turn the templates over. Cut the leather with a sharp knife, pressing hard enough to cut clear through the first time.

Punch the lace holes with a leather punch, or if you want tight seams, use a tenpenny nail. These holes must be opened up with an ice pick when you lace, but as the moccasin dries, the leather shrinks tightly about the laces and makes the shoe watertight. Note that the lace holes in the bottom of the moccasin are spaced almost twice as far apart as the holes in the toe. You must pucker or "full" the bottom piece between each stitch by pulling on the lace until each pair of holes are drawn opposite and even.

Bevel or skive off the edge of each bottom around the toe on the wrong side or inside. The smooth side of the leather is the right side and the outside. Soak the bottoms in water until thoroughly softened, but do not soak the toe pieces.

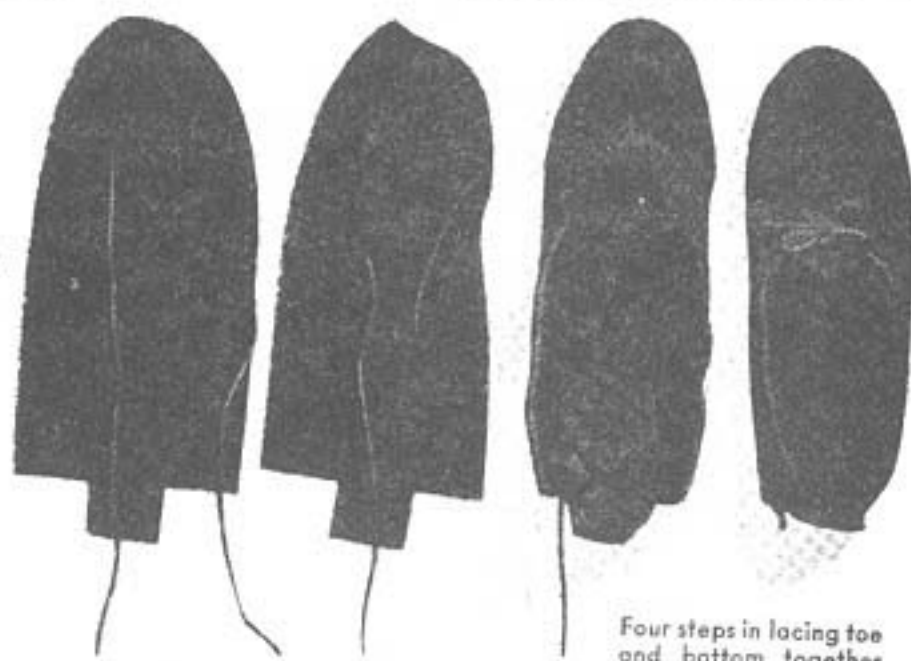
Count off holes on either side and begin to lace through the center hole of each piece. Draw the $\frac{1}{8}$ -in. lace halfway through and lace down one side of the moccasin with one end. Pull each stitch very tight, butting the edges of the leather together. Do not let them lap; the seam should be flat. Keep the lace flat and untwisted. Pull very hard until each pair of holes are opposite. Lace through the last pair of holes twice and push end of lace under the last two stitches.

Lace up the other side and then, while the moccasin is still damp, either jam the toe full of paper or slip it over a piece of wood roughly shaped like your foot and hammer the seam until it is perfectly smooth and the laces are beaten down flat.

Slip the moccasin on your foot and fit the heel. Make the two heel cuts deeper if necessary, and cut off the ends of the two tabs which butt together until they fit snugly. (All pattern sizes are purposely made a trifle long for fitting.)

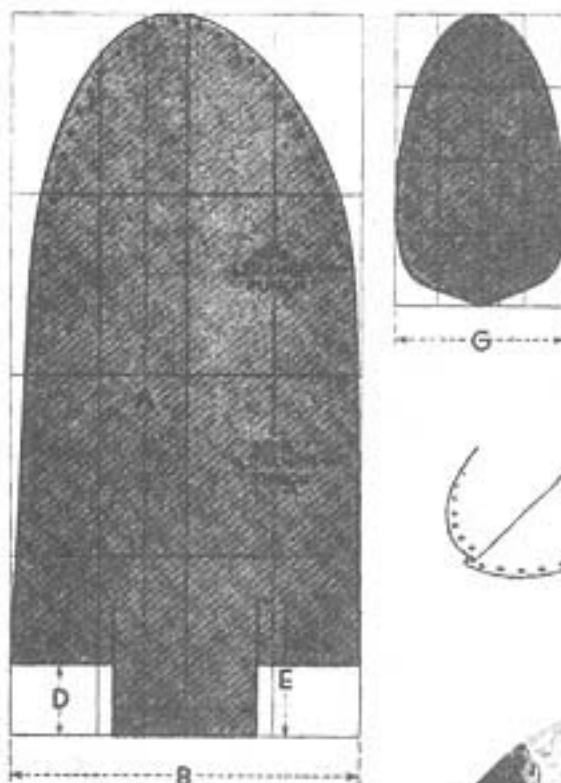
Lace up the heel as shown, lay it over some solid rounded object, and hammer the bends in the leather. String in the 3/16-in. ties, making the loop across the heel come outside to prevent chafing. The ends of the ties are tied into a double bow knot on top of the foot. Soak the moccasins in water again until soft, slip them on your feet over woolen socks, and walk until the leather is dry.

The pattern sizes are for medium to wide feet. If your foot is quite slim, make the patterns first on paper, then fold each piece lengthwise down the center and take a small tuck as shown in a sketch.



Four steps in lacing toe and bottom together

Using leather punch to make holes in bottom



The patterns. In drawing them, follow dimensions below



Sketch at left shows how to narrow a pattern, if necessary. Above, method of fastening end of the lace



The heel tabs are cut and fitted until the moccasin conforms smoothly to the foot

DIMENSIONS FOR PATTERNS

Length in.	A	B	C	D	E	F	G
5	13 1/4	7 1/2	2 1/4	1 1/4	2 1/4	3 1/4	3 1/4
6	13 1/4	7 1/2	2 1/4	1 1/4	2 1/4	3 1/4	3 1/4
7	14	7 1/2	3	1 1/4	2 1/4	3 1/4	3 1/4
8	14 1/4	7 1/2	3	1 1/4	2 1/4	3 1/4	3 1/4
9 1/2	14 1/4	7 1/2	3	1 1/4	2 1/4	3 1/4	3 1/4
10 1/2	15 1/4	7 1/2	3	1 1/4	2 1/4	3 1/4	3 1/4



The toe is hammered over a rounded piece of wood



Vacuum Tube TESLA Coil Does Fascinating STUNTS

From Modern Mechanics 1931

Light bulbs and spinning wires which glow with weird effects, cigarettes which light mysteriously—these are a few of the stunts you can do with this vacuum tube Tesla coil.



One of the spectacular effects that can be created with Tesla coil is shown above. Spinning wire shoots off glowing sparks when current is turned on.

THE older types of Tesla coils, calling for a high tension transformer and spark gap for excitation, were undoubtedly interesting and instructive, but the one shown in the accompanying photographs and sketches will prove much less expensive to

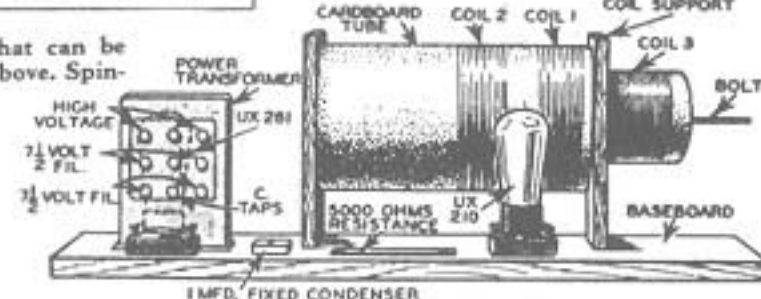
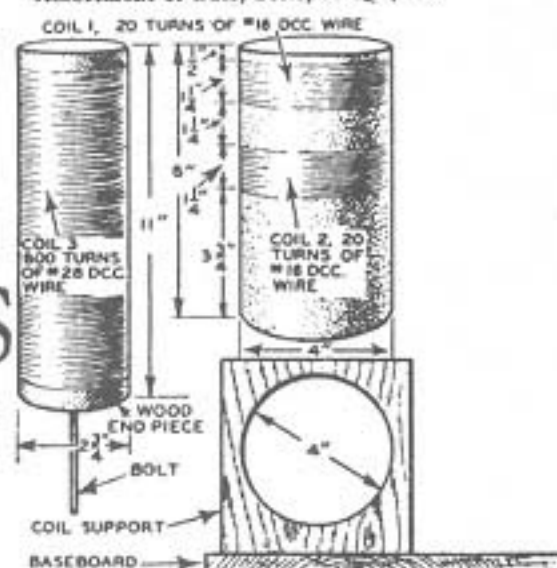


Fig. 1. Here is a side view of the vacuum tube Tesla coil, showing the layout of parts on a baseboard. For higher power, an additional tube may be used, wired up in parallel with the 210 tube. yet will provide plenty of sure fire fun and spectacular results. It makes use of many

radio parts and therefore should prove very inexpensive to construct by those readers possessing a stock of spare radio "junk." It is simply a matter of plugging in to the 110-volt electric light line to carry on an almost endless number of interesting and instructive experiments in high frequency currents. You will need the following parts:

- A baseboard 18 in. long by 10 in. wide.
- Cardboard tube 8 in. long, 4 in. diameter.
- Cardboard tube 11 in. long, 2 1/2 in. diameter.
- Two radio UX sockets.
- Transformer giving about 500 volts and provided with two 7 1/2-volt filament windings.
- One 210 type radio tube.
- One 281 type rectifying tube.
- Two wooden supports for the 4 in. tube.
- One 5,000-ohm grid leak about 5 watts rating.
- One 1 Mfd. fixed condenser to stand at least 500 volts breakdown voltage.
- 50 ft. No. 16 DCC wire.
- 700 ft. No. 28 DCC wire.
- Hookup wire.
- Assortment of nuts, bolts, screws, etc.



The hookup and layout of parts indicated in Fig. 2 should be followed to the letter to insure best results. Place the transformer at the left end of the baseboard near the rear. Then mount one of the sockets in front of it for the rectifying tube (281). To the right of the tube mount the fixed condenser. Mount the two coil supports to the right of the transformer. Then in front of this coil mount the remaining socket for the 210 oscillating tube.

Now comes the winding of the coils. First wind those called Coil 1 and Coil 2 on the 4-inch tube. These consist of 20 turns each of No. 16 DCC wire. Note the dimensions and spacings on the diagram (Fig. 2). Wind closely and tight and space them 1 1/4 inches apart. Wind in the same direction and secure the ends by any manner at hand. Wind in the same direction as the two former coils and secure each end to a bolt, the right hand one projecting out two or three inches from the end.

Mount the 4-inch coil in the supports as shown. Now slip the 800-turn coil (Coil 3) inside the larger tube and by means of blocking or little angle pieces, support it in the center of the large tube equidistant from all sides as illustrated in Fig. 4. Solder all connections not secured by connectors or binding posts and make all leads as short as possible.

Hookup wire can be either bare copper wire covered with spaghetti, or any type so long as it is well insulated and about No. 18 gauge.

Start with Coil 1. Connect the outside lead to one side of the fixed condenser and to one side of the filament winding used to light the rectifying (281) tube. The inside lead of Coil 1 then connects directly to the plate terminal on the 210 tube socket. Now connect the inside lead of Coil 2 to the grid binding post on the 210 tube socket and connect the outside lead to one end of the grid leak resistor. Connect the other side of the grid leak to the inside end of Coil 3 (next to the transformer), to the iron core of transformer to filament post of 210 tube, to one side of the high voltage winding on the transformer and remaining side of fixed condenser. The remaining side of the high power winding is then connected direct to the plate of the 281 tube. Each filament winding is then connected to the filament terminals of the two tube sockets. This completes the wiring. The transformer primary should of course be provided with a cord and plug.

To test first plug in the transformer. This will light the tube filaments. Then, to see if the high voltage is energizing the Tesla coil, run a screwdriver or other metal tool up and along the bolt at the protruding end of Coil 3, as demonstrated in the photo on page 152. It should draw sparks as it passes over the threads and will prove it is working. If no show of energy occurs go over the wiring thoroughly (first pulling the plug) and look for disconnected wires or poorly soldered joints. When properly hooked up it will surely work and you are then ready for a number of highly fascinating experiments.

With your Tesla coil operating properly you are ready for some of the most weird and interesting experiments imaginable. First, do not fear a shock. Slight burns may result if taken on the bare flesh but if one holds a metallic object in the hands no sensation is noticeable. Therefore, there is no danger.

First let's see what can be done about drawing a spark from the bolt on Coil 3. Hold a metal tool in the hand and gradually bring it near the bolt. When the breakdown distance is reached sparks will jump between the two metals similar to lightning. Too great a voltage must not be used, but any voltage from 350 up to about 750 volts is perfectly safe.

Now let's try a little experiment with an electric light bulb. If you can get hold of a bum one so much the better. First fasten a small metal ball to the end of the bolt. Then, holding a 15 or 20-watt bulb by the glass, bring the metal ferrule near the bolt. As it approaches it will commence to glow and change colors according to the gas in the bulb and the power of the coil. Get a bulb in the "Five and Ten" marked "made in Japan" if you want to see some fascinating effects.

Here is another fascinating demonstration. Fasten a very fine, stiff wire to the bolt and bend it up and outward in a wide curve as illustrated in Fig. 5. Plug in the coil and

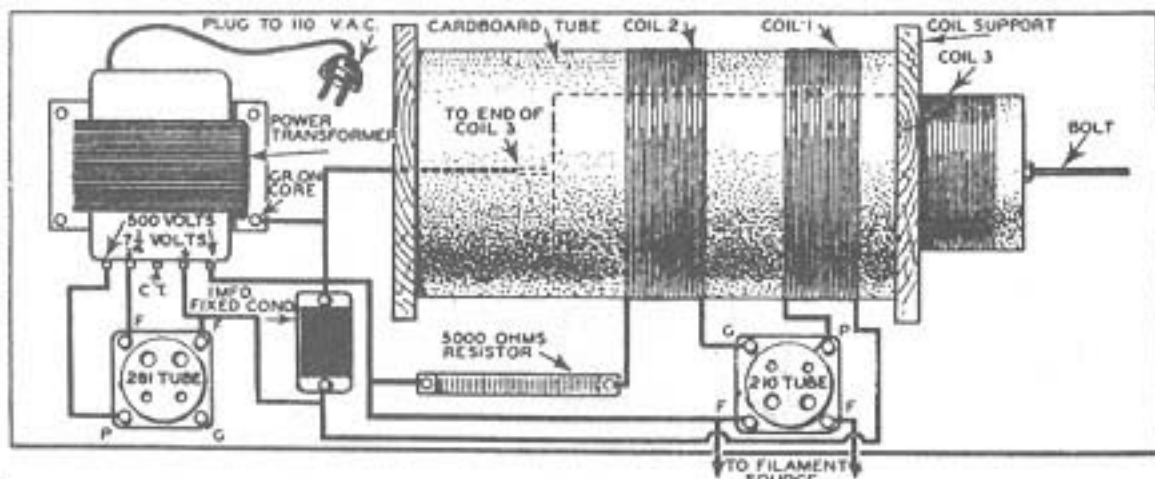


Fig. 2. Coils 1, 2 and 3 are wound on cardboard tubes to dimensions given in top drawings. Lower drawing gives layout of parts on baseboard and hook-up for tubes and coils. Coil 3 is inserted in coils 1 and 2 as shown. Filament leads of 210 tube are wired to 7½ volt terminals of transformer.

Spinning Rotor Emits Changing Corona Discharge in Fascinating Stunt

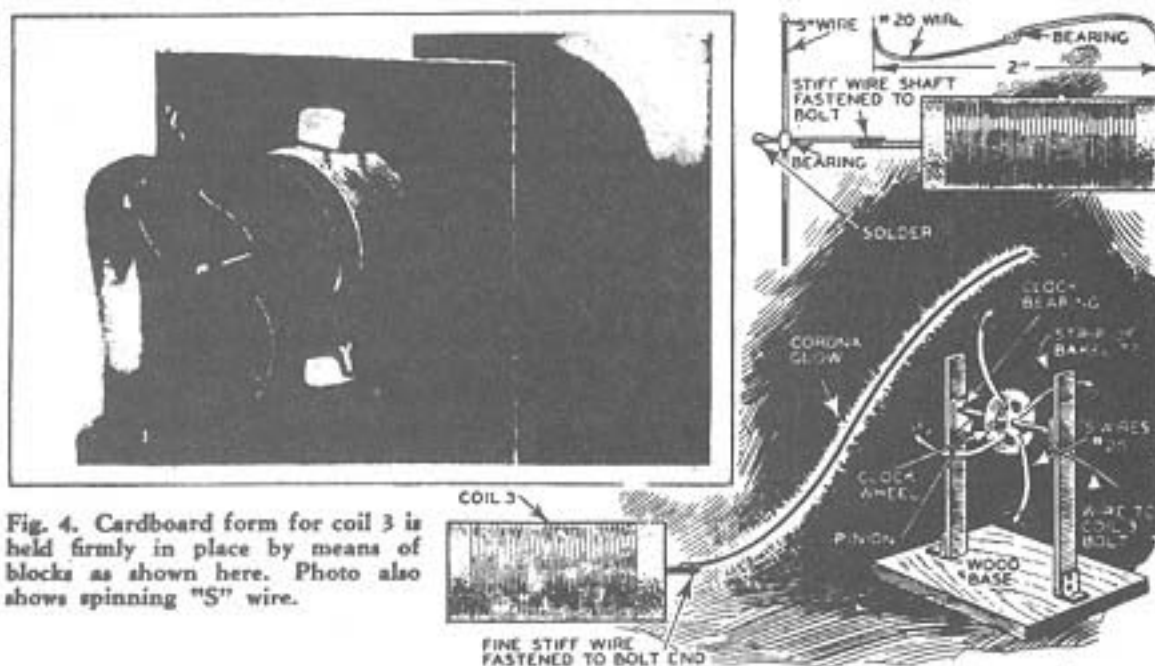


Fig. 4. Cardboard form for coil 3 is held firmly in place by means of blocks as shown here. Photo also shows spinning "S" wire.

Fig. 5. Spinning "S" wire and straight wire for experiment on corona discharge is fastened to bolt as shown. At right is rotor made from clock parts which produces fascinating corona glow.

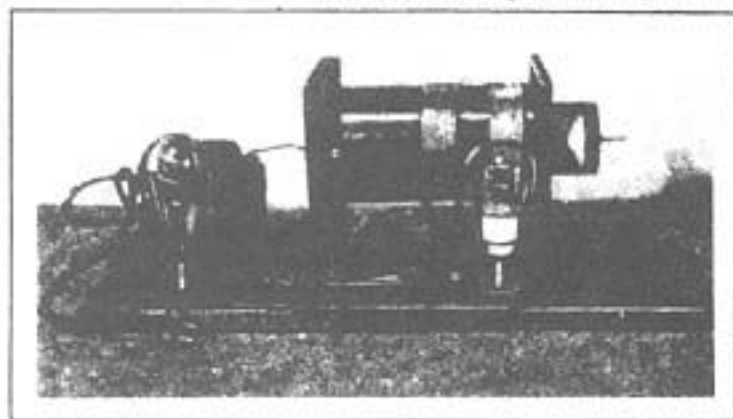


Fig. 3. Here is the completed vacuum tube Tesla coil, ready to produce fantastic light effects. Power of tube is decreased when experimenting by rheostat in primary of the transformer.

watch the result in a darkened room. Varying the output voltage will change the glow around the wire and at the very end will be seen a very concentrated discharge of fire.

Here is one of the most spectacular stunts of all. It is a rotor spinning from the high frequency oscillations and emitting a changing corona discharge ever fascinating and beautiful. Bend a piece of fine wire such as

No. 22 or 24 into a wide S as shown in Fig. 5. Slip this over a piece of stiff wire fastened to the end of the bolt horizontally. The wire must rotate freely and be free from kinks or corners. Start the coil and watch the S wire spin. It will rotate at terrific speed well up into several thousands of R.P.M.s. All around the circle will be seen an even number of brush discharges and the peculiar thing is

that they will always be an even number.

Here is a way to mystify the crowd. Hold a match head near the bolt. No effect is noticed. Then wet the head so it is soaking. Hold it near the bolt again and it lights! The dry head was non-conductive but the wet head acted as a metallic conductor and soon ignited from the spark produced. Done with

the bolt and coil hid behind a thin partition makes the trick doubly mysterious.

As the user becomes accustomed to the action of his Tesla coil he will discover many more interesting and instructive uses for it. Common things can be utilized to produce many weird results and spectators will never tire of watching the effects of its action. As

before stated, there is not the least danger in its effects. But, don't get careless with the direct output of the transformer itself. The current produced is at a much lower frequency (6 cycle) and 500 volts or more at this frequency will give quite a kick if taken through the body.

How to Mend Shoes

BY FRANK M. RICH

EVERYBODY wears out shoes, and "by the same token" everybody ought to know how to mend them. The statement that shoe profits are "paper" profits only serves to confirm a lurking suspicion that paper is involved somewhere, a suspicion first engendered by the rapidity with which many shoes wear out. "Cobbling" is not high art but it is good economy, and he who has a pair of old shoes that can be renovated by straightening up the heels and adding new taps, or half soles, and does these things, contributes his bit toward reducing the cost of living.

An outfit of shoe-repairing tools and materials is simple and inexpensive, and the whole can usually be purchased for less than the price of a set of soles.

Before proceeding with the actual work, it is well for the "cobbler" to familiarize himself with the various parts of a shoe, as shown in the small drawing, after which he is prepared to tackle a job of half-soleing.

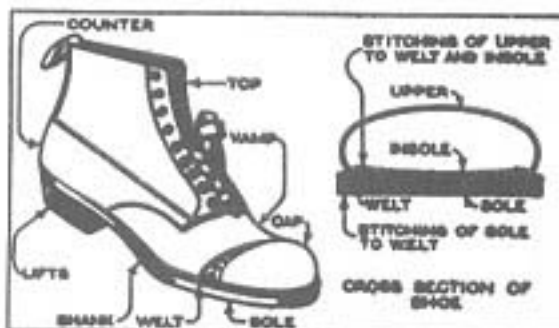
First, the shoes are set on the leather and the new taps are marked out and cut a trifle larger than the old sole; these pieces are soaked for a few minutes in warm water, to soften the leather. While the leather is thus "mellowing," the old sole is removed, as in Fig. 1. Cut the

thread with a knife, if the soles are sewed on, and, if the shoes have never been re-soled, the worn sole is cut off at the shank, as in Fig. 2, paring the shank down to a thin taper or scarf, to make a neat splice with the new sole, which should be similarly scarfed. The leather is removed from the water and pounded on the last, evenly and thoroughly, with the hammer, to "harden" it. The shoe is then placed on the last and a piece of shoemakers' tarred felt, half the length and width of the sole, is placed under the sole to prevent squeaking. If the toe of the shoe has been worn down so that the welt is not in good condition, a tapering piece of leather is tacked to the toe to build it up, as in Fig. 3. The sole is fastened in place with four nails, as shown in Fig. 4. In nailing, the

pegging awl is used to start the nail; the hole is not made too $\frac{1}{2}$ -in. intervals along the line, and the deep, just deep enough to hold the nail nails are driven in. Be sure the nails

in position. The nails are not driven perpendicularly but with a slight slant toward the center, to hold the sole more securely.

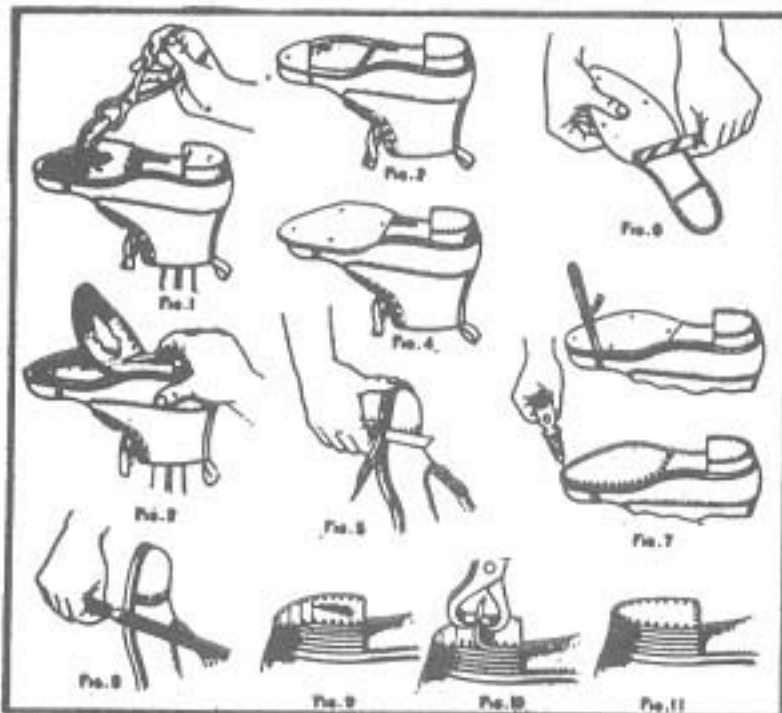
After the sole has been tacked to the shoe as shown, the surplus leather around the edge is trimmed away, as in Fig. 5, so that it will be approximately flush with the sole; this is necessary so that the repairman will have an approximately cor-



A Study of the Component Parts of the Shoe is Suggested before Starting to Work

rect outline to work from in order to get the nails in evenly. Figure 6 shows how the tap should be pared, or scarfed down, at the shank to make a neat joint at the point where the new sole laps over and joins the old one.

A line is scribed with a compass, or by other means, as indicated in Fig. 7, at a point from $\frac{1}{4}$ to $\frac{1}{2}$ in. from the edge of the sole; this depends upon the size of the shoe and the width of the welt beyond the upper. Then awl holes are made at



Almost Anybody can Learn to Do a Good Job of Shoe Repairing in a Short Time, and Even If One Is Not Naturally "Handy with Tools," the First Attempt will Be a Revelation. Figures 1 to 8 Show the Various Steps in Half-Soling a Shoe, and Figures 9 to 11 Show How Worn Heels are Repaired

strike the last and clinch, and pound the heads down flush with the surface. If any nails bend over, withdraw them and put in new ones. Allow the leather to dry slowly, and then finish off the edge of the sole with a rasp, or a piece of broken window glass, which makes a good scraper. If a finer finish is desired, sandpaper can be used. After the soles have been finished the raw edges are coated with shoe polish to correspond with the color of the shoe.

Normally most persons wear the heel off at the back, as shown in Fig. 9, while others walk so that the heel runs over at either side. In such cases the worn top pieces, or "lifts," as they are called, are removed, as in Fig. 10, and the projecting nails or pegs pulled out; then the heels may be built up of tapered pieces in the same manner as described for repairing a worn toe. These pieces serve to use up the odds and ends of leather. The small wedge-shaped pieces are tacked to the heel, and the bottom lift is applied in exactly the same manner as the sole, the finished job appearing as in Fig. 11. Of course there is no objection to removing all the worn lifts and replacing them with new ones, if leather is available.

Before the mended shoe is ready for wear, it is well to go over the nail heads with a file to take off any slight projections; examine the inside for nails and pound down thoroughly any projecting points or prominent clinches. A lining of thin leather cemented over the insole is desirable, especially at the heel.

Anybody can learn to do a good job of shoe repairing in a short time, and even if one is not naturally "handy with tools," but uses care in nailing and cutting, the first attempt will generally be surprisingly good.

An Ice Creeper

Popular Mechanics, 1919

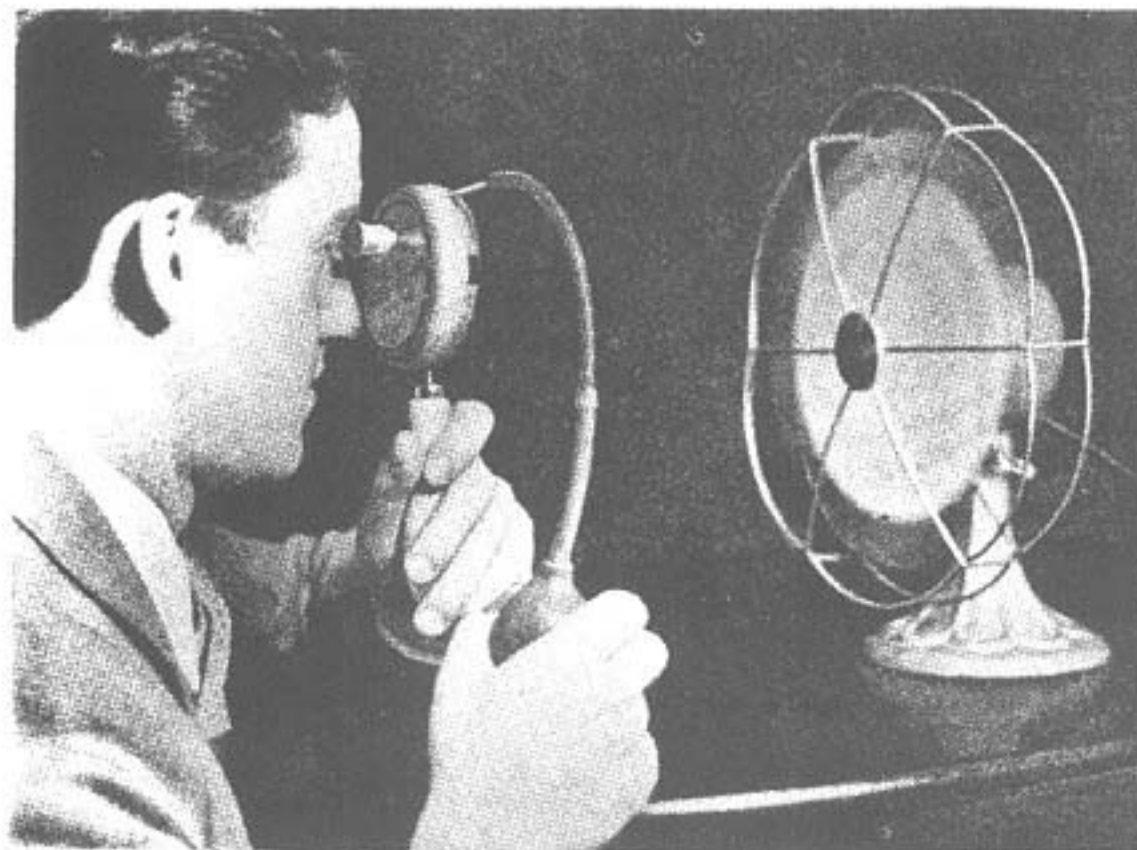
The illustration shows a one-piece



ice creeper for the heel of a boot or shoe. It is made from sheet steel with the arms bent up to receive a strap for buckling it in place on the boot heel. The zigzag cuts in the bottom part are turned down for engaging the ice.

Whirling Wheels Stand Still

When Viewed Through HOMEMADE STROBOSCOPE



This simple stop-motion device, driven by compressed air from an atomizer bulb, "freezes" rapid mechanical motions. Here it is being used with a disk of special design on an electric fan.

Popular Science Monthly, August 1936

*This Article Tells How
To Make and Use a Device
That "Freezes" Machinery
And Other Moving Objects
For Interesting Tests*

EVEN the simplest device of modern science would look like black magic to our ancestors, if they could come back and see it work. Imagine, for instance, the wonder which you could arouse in your great-grandfather's mind if you asserted that you could read a word chalked on the side of a rapidly whirling flywheel—and actually did read it! Yet this is a very simple feat to perform with the modern stop-motion device called a stroboscope, which today enables engineers to obtain "still" views of rapidly whirling and vibrating mechanisms and study them as if they were per-

fectly motionless, thus obtaining valuable clues to the solution of problems in lubrication and efficient machine design.

The principle of the stroboscope is so simple that it is easy to build one out of ordinary materials and carry out a wide variety of interesting and amazing experiments. All that is necessary is to make a disk in which a narrow slit is cut near the edge, and devise means for rotating it rapidly in a suitable housing provided with a viewing hole in line with the path of the slit. You look through the eyehole at a whirling electric fan, for example, and speed up the disk. When its rate of revolution becomes equal to that of the fan, the blades will appear to slow down and stop—just as if the current had been turned off! If a clipping with a few words of large type has been pasted on one of the blades, you can read it, although the fan is nothing but a blur to the unaided eye!

And you can not only "stop" the mo-

tion; you can even "reverse" it. If the speed of the stroboscope is increased to exceed that of the fan, the whirling blades will appear to be running backwards.

Another interesting effect is produced when the disk with the slit is rotated at twice the speed of the fan. When this velocity is

attained, the fan will seem to slow down and stop as before. If the fan has an even number of blades it will appear quite normal; but if the number is odd, you will see twice as many blades. Similarly, if you have attached a picture (of a horse, let us say) to one of the blades, you will now see *two* horses motionless at opposite sides of the fan.

A moment's thought will reveal the principle which makes these surprising effects occur. It is called the "persistence of vision" and is the same principle which makes motion pictures possible. Here is how it works:

When the slit in the revolving disk crosses the eyehole through which you see the fan, you get a split-second, instantaneous view of the horse picture. This image remains on your eye's retina for a fraction of a second. When the disk is revolving at the same speed as the fan, you get a succession of glimpses of the picture at the same spot in its circular path, and these repeated impressions are blended by the persistence of vision into what looks like a steady picture of the horse at the same spot.

The appearance of *two* horses, when the disk's speed doubles that of the fan, is accounted for in the same way, except that you get two glimpses of the horse during each revolution of the fan, or one every half revolution. The doubled impressions accordingly produce two apparently motionless pictures of the horse at opposite sides of the fan.

Now, having cleared up the principle upon which the stroboscope is based, we will consider a practical change which we must make in building our simple piece of apparatus.

The motive power which we will use—compressed air acting on tiny "turbine" blades attached to the disk—is incapable of developing a speed equal to that of a fan run by an electric motor. We must resort to a trick to multiply the number of glimpses caught in each second. This can be done simply by cutting more slits in the disk! If we provide four slits instead of one, it amounts to the same thing as running the single-slit disk four times as fast, for we get four times as many glimpses of the horse every second.

For building your stroboscope, you will need only some sheet brass or heavy tin; the rubber bulb from an atomizer; a flat, round shoe-polish can and cover; a wooden file handle; a flat-headed wood screw; a bit of one-eighth-inch brass tubing; and a long, thin brad that fits loosely in the bore of the tubing.

If you find it difficult to obtain suitable tubing, you can roll up a piece of thin metal and run solder between its layers to make a solid tube with a bore of about one-sixteenth-inch.

If your shoe-polish box is not more than three and one-fourth inches in diameter, you will not need to alter the dimensions which the plan gives for the disk. Otherwise, modify the size of the disk sufficiently to bring its edge within about one-fourth inch of the rim of the box.



Cut the disk out of your sheet metal, and solder a piece of the tubing through its center as a bearing to run on the nail. When the vanes are cut and bent on the edge of the disk, and the four slits cut to the dimensions indicated, the moving part of the device is complete. It should spin freely and evenly on the nail, which must be soldered firmly at the center of the blacking-box housing.

Now punch a hole in the edge of the box and solder the air tube in position as shown in the plan. It should be approximately tangent to the edge of the rotating disk, so that the jets of air forced out by the atomizer bulb will strike strongly upon the vanes to propel the disk.

Then cut an "outlet vent" in the side of the housing, as shown, so that the air will clear out rapidly after impelling the vanes. Now it only remains to solder on a flat-headed wood screw to the edge of the polishing-box housing, and screw it into the wooden file handle. This completes your stroboscope, and it is ready for use. A drop or two of oil in the tube bearing will make it spin more freely. A scratch made across the joint of the tin housing when the two viewing holes are in line, with the disk removed, enables you to get the holes in line easily in assembling the device with the disk in place.

JUST a word about the rubber atomizer bulb which furnishes the motive power. It should

be fairly large, and must be provided with a one-way valve. Any drug store should be able to supply you with the bulb alone, or with a cheap throat-spray atomizer from which it can be temporarily removed for your experiment.

Further details of construction can be gleaned from the scale plan and photographs. The exact sizes given are not important, with the exception of the width of the slits. These should not be over one-thirty-second of an inch. Wider slits will give less sharp images. I cut each slit by drilling a row of holes in the disk and then filing them into a continuous slit.

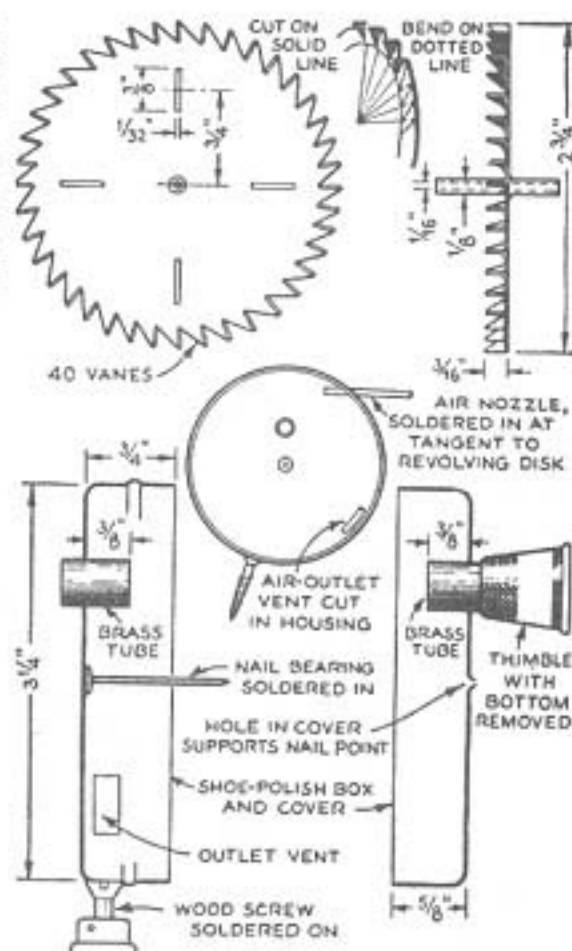
The construction given calls for the simplest materials possible. If you have a metal-turning lathe, and some skill as a mechanic, you can construct a much more workmanlike job than the one specified.

With this simple apparatus, you will find it easy to "stop" mechanisms of any moderate speeds. You can, for example, arrest the up-and-down motion of the poppet valve on a gasoline engine, and see it motionless. Or you can "stop" the vibrating motion of the hammer on a door bell.

In fact, having a disk with four slits will enable you to exceed the speed of the electric fan sufficiently to see more than two horse pictures on the circular card attached to it, as shown in the illustration.

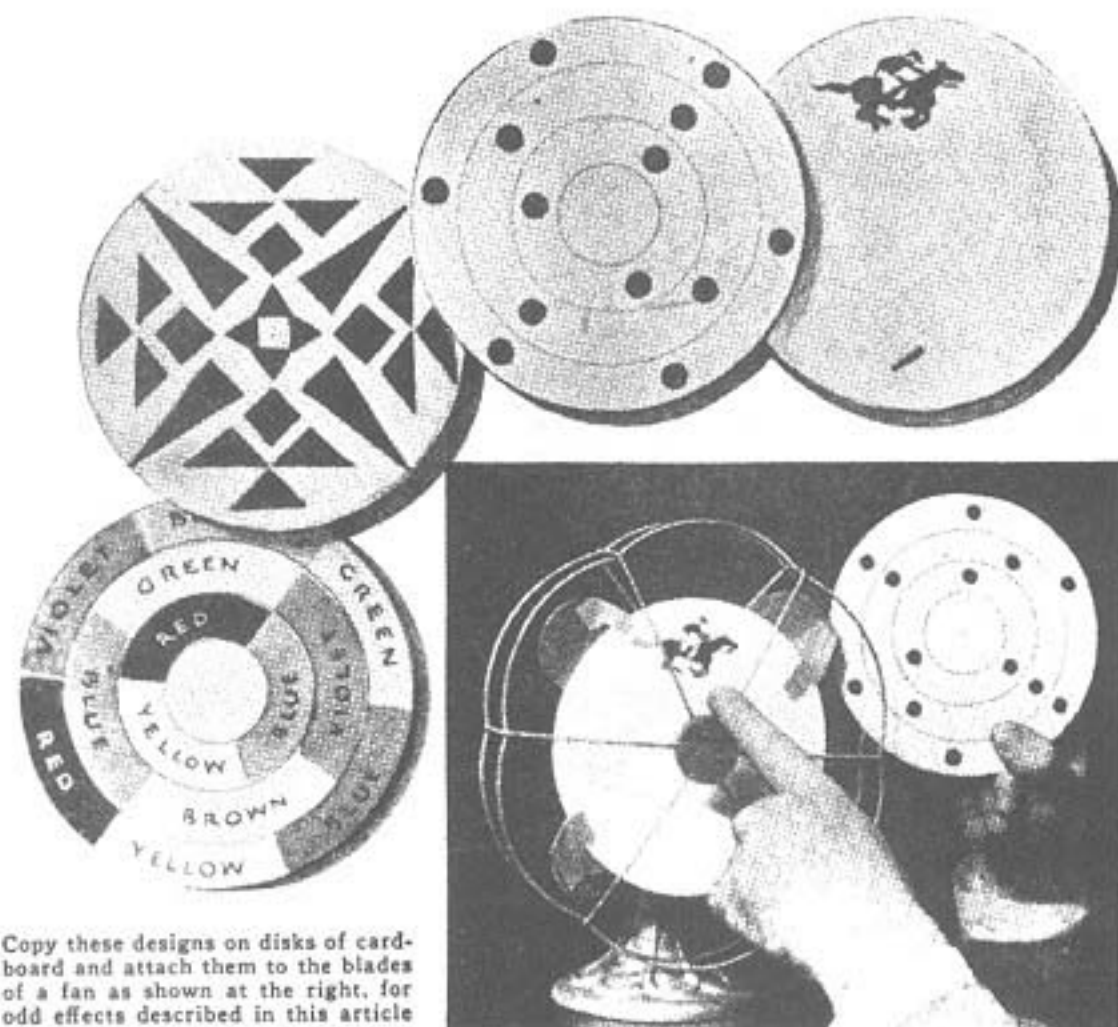
Interesting variations on the horse picture can also be tried. Some of these are illustrated, and can be reproduced in larger size and attached to the fan blades.

One of these has three concentric circles of black spots. The inner circle has three dots, equally spaced; the middle one has four spots, and the outer has six. When attached to the fan blades and viewed through the rotating disk of the stroboscope, one of these circles of dots will be seen to spin in one direction,



A shoe-polish box, a rubber bulb, and a few other odds and ends are all you need to make this interesting device. The details of construction are shown in the photo and drawing

while the others spin the opposite way. An increase or decrease in the disk's speed will re-



Copy these designs on disks of cardboard and attach them to the blades of a fan as shown at the right, for odd effects described in this article

verse the direction of motion, or make one circle stop while the others are still moving. Greatly increased speed will multiply the number of all the spots.

ANOTHER fascinating experiment can also be tried with a circular card on which colored areas are substituted for the concentric circles of dots. In this case, each of the circles of blended color produced by rotating the card can be slowed down and "split" into the primary colors from which it is combined.

If a simple geometric design is drawn upon one of the circular cards, it can be made to change its form and produce differently shaped figures. These shapes melt from one into the other as the speed of the stroboscope's disk varies.

Another interesting subject for viewing through your stop-motion device is an electric bell with one end of a rubber band attached to the hammer, and the other end to a nail. When the bell hammer is put in motion, the rubber band is thrown into a spindle-shaped figure, as shown in one of the illustrations. Now view the rubber band through your stroboscope. When the slits pass the peep hole at the same frequency as the hammer's vibrations, the band can be stopped in a "still" curve. This curve will shift from the left to the right side of the spindle as the speed of the disk varies slightly. A longer rubber band will vibrate in two spindle shapes, which the stroboscope "freezes" into an S-shaped curve.

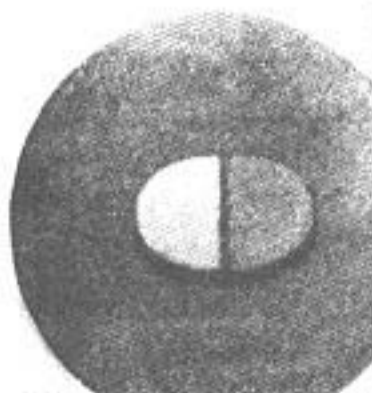
If you can obtain a small neon lamp of the plate type shown in one of the photographs, you can separate and actually see the impulses of ordinary alternating current! This is possible because only one of the plates of the lamp is glowing at a time, while the other plate is totally dark. With ordinary sixty-cycle current, this gives 120 flashes of light a second, which the persistence of vision fuses into continuous light. When you look at the lamp through the stroboscope, you can speed the disk up until one of the plates seems to glow all the time, while the other is dark. This, incidentally, enables you to measure the speed of your disk. If three of the four slits are covered with bits of adhesive tape, leaving only one open, the disk must be rotating sixty times a second when one plate of the lamp remains dark.

THE alternate dark and light flashes of a neon lamp running on alternating current is, in fact, the basis of an entirely different kind of stroboscope. You can prove this by spinning a top with a row of black spots pasted around it, and then watching it slow down in the light of a flashing neon lamp. For success in this experiment, there should be no other light present in the room.

When the top slows down to exactly 120 revolutions a second, you will be able to see it momentarily motionless, for the flashes from the lamp, coming at the same rate, give you glimpses of the black spots always at the same points in their revolution. The spots accordingly appear motionless, just as they would through the slits of the rotating disk of your compressed-air stroboscope. The successive glimpses you get are given by the light flashes instead of slits; that is the only difference.

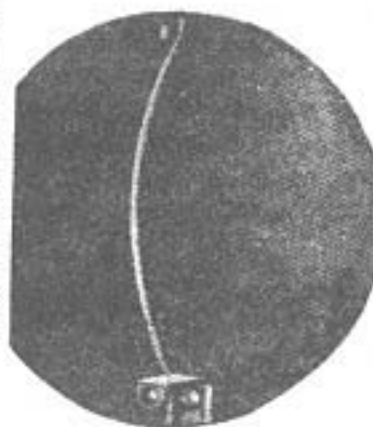
Any motion occurring at regular intervals, either circular or vibratory, is an interesting subject upon which to try out your stop-motion device. Try it with the waves formed on water when a faucet drips rapidly into it. Try it on the wheels of cars passing in the street.

You will be able to "stop" the spokes and



A rubber band, attached to the hammer of an electric bell as illustrated, vibrates when the bell "rings." When viewed with the stop-motion device, it "freezes" in a curve as at right

You can actually see the impulses of ordinary alternating current by looking at a glowing, plate-type neon lamp with your stroboscope. When the disk is rotating at the proper speed, one of the plates seems to be glowing continuously, while the other remains dark, as shown in the circle at left



then make the wheels reverse their direction, just as you have seen them do in moving pictures. This shows that the moving-picture camera is itself a sort of stroboscope.



From Midnight Globe, Dec. 20, 1977

Getty's Rules For Getting Rich

If you're looking to get rich, here are the 10 most important rules according to the late J. Paul Getty, who was one of the world's wealthiest men:

- 1: Go into business for yourself in a field you know and understand.
- 2: Produce more and better goods or services to more people at less cost.
- 3: Be thrifty — practice economy wherever possible.

4: Don't miss opportunities to grow — but don't over-expand wildly.

5: Run your own business — you should never expect someone else to do it as well as you can.

6: Be alert for new ways to improve your product.

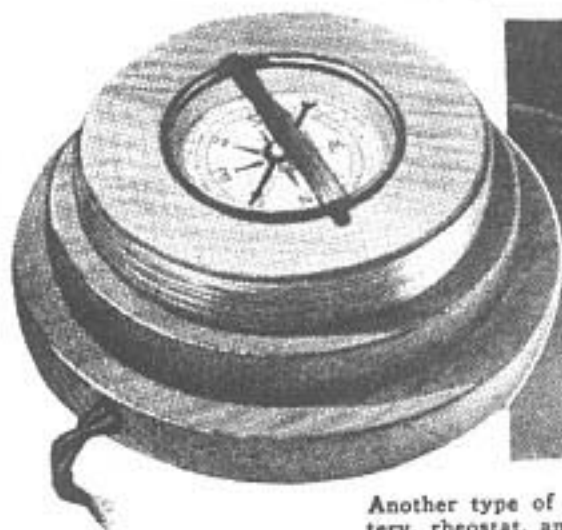
7: Bet all you've got and all you can borrow on improvement when you think the risk is justified.

8: Look constantly for bigger markets.

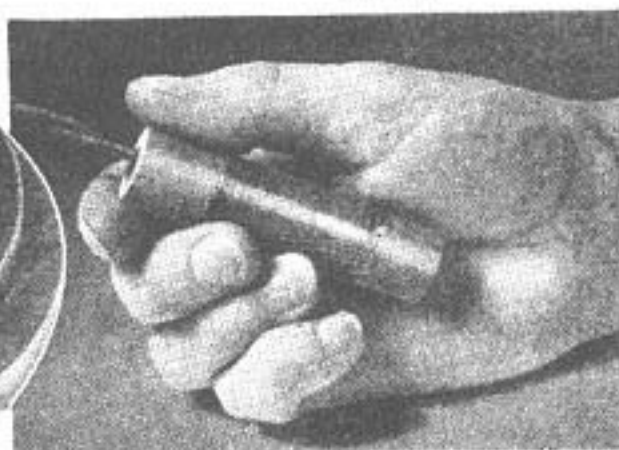
9: Always stand behind your work and honor guarantees.

10: Use your wealth to improve conditions for others, beginning with employees and stockholders.

These rules worked for him, says Getty in "How To Be Rich," published in paperback by Playboy Press. He promises that "they'll work for you, too."



Another type of detector consists of a hand electrode, dry battery, rheostat, and homemade galvanometer like that at the left



TWO SIMPLE WAYS TO MAKE A Lie Detector

By KENNETH MURRAY (Popular Science 1936)

With it you can entertain your friends by performing miraculous card tricks, finding hidden objects, detecting falsehoods, and doing other stunts and scientific experiments

IF YOU think that you can tell a lie and get away with it, test your cleverness against this homemade model of a lie detector or polygraph, as it is often called. With uncanny accuracy it uncovers falsehoods as quickly as you can tell them. While your voice is saying "no," your body says "yes" and leaves a visible record of the truth on this device.

Much amusement can be had by subjecting friends to different tests. For example, have some one choose one playing card from a dozen. Pass them one at a time before the eyes of the person undergoing the test and when he sees the selected card he may say "no," but the indicator of the lie detector will jump and tell that he is fibbing. Although your friend may give no visible indication of this, the sight of the card he chose will instantly cause an increase in his blood pressure, and this is recorded by the instrument. After some one has hidden an object in another part of the house, unknown to you, name the different rooms to him and watch the lie detector. After you have discovered the correct room, it is easy to narrow down the location to the exact spot in which the object is hidden.

Tests such as these always cause amazement, and it is just as well not to explain how the instrument works or that there is anything simple about it. Neither is it advisable to ask serious questions of any one undergoing the lie-detector test, for the device will always indicate when the truth is being told, sometimes with embarrassing results.

This model, although it can be easily constructed from simple parts, works on the same principle as the famous lie-detecting instruments used by criminologists in obtaining confessions of guilt from law violators. It is based on the sphygmometer, a pneumatic device used by physicians for testing blood pressure. Another type of lie detector, which operates electrically and is equally accurate and simple, will also be described.

The "mechanical mind" of the lie detector is an indicating device that records variations of blood pressure on a moving strip of paper. Normally it will make a

series of jagged lines, each stroke of equal length. When the subject tells a lie, however, his blood pressure will momentarily shoot up, and the lines made by the indicator will be longer. Since the device itself is so simple, it is advisable to conceal it in a box so as to hide the mechanism and give it as mysterious and complicated an appearance as possible.

The box illustrated is 9 in. wide, 5½ in. deep, and 5½ in. high. The apparatus is attached to the top, in which is cut a 4½ by 2½-in. window, which shows a section of the movable paper tape and the indicator hand. The latter is a narrow strip of metal to the end of which is attached either a pen point or a piece of soft pencil lead.

Attached to the other end of the hand is a disk of tin which rests against a rubber diaphragm (from a heavy toy rubber balloon) stretched over the mouth of a clay pipe. A small wire spring holds the disk against the diaphragm, the arrangement being shown clearly in one of the photographs. Over the stem of the clay pipe is slipped the end of a length of rubber tubing connecting with a rubber bag wrapped around the subject's upper arm. Obviously, any variation of air pressure will affect the

rubber diaphragm and cause a movement of



This lie detector shows all changes in the subject's pulse beat. It is being used to find a certain card

the indicating hand, this being recorded on the paper tape.

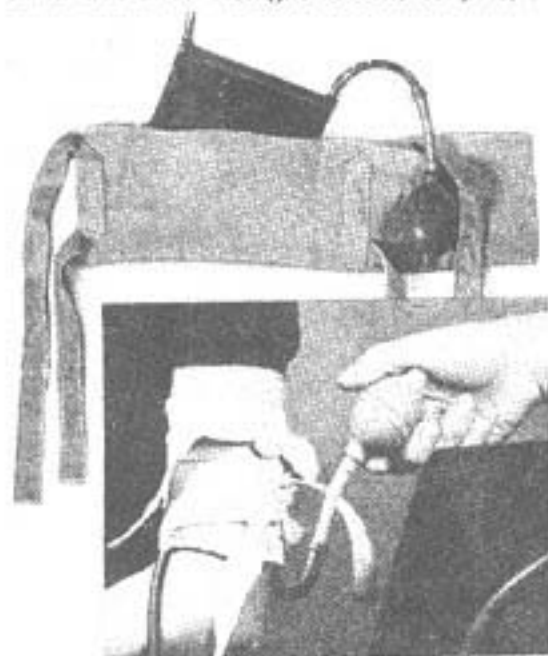
Ordinary adding machine paper can be used for the tape, the roll being supported on a dowel as shown. Another dowel, which ends in a knob outside the box, is used as a take-up spool. As each question is asked, the knob must be turned slowly and uniformly. The paper could be made to unroll automatically by means of a spring or electric motor placed inside the box, but this would, of course, make the construction more complicated.

One illustration shows the band which is wrapped around the upper arm of the person undergoing a test. A rubber bag is made from a piece of automobile inner tube long enough to reach around the arm. Cemented

into one side is the end of the rubber tube from the indicator box, and into the other side is connected the bulb from an ordinary atomizer. Sew the bag into a cloth envelope with tapes attached so that it can be tied in place. Squeezing the atomizer bulb will inflate the bag and cause pressure around the arm. The subject's own blood pressure or pulse will cause fluctuations in the air pressure, these being recorded on the tape as illustrated.

Probably you have observed that, when excited or frightened, your perspiration glands will become more active, this being most noticeable in the palms of the hands, which will sometimes become quite moist. Another type of lie detector, known as the psychogalvanometer, takes advantage of this fact, and with it you can carry out the same experiments suggested heretofore. It is very sensitive, despite the relatively slight increase in perspiration that occurs when a person tells a lie.

An electrode is grasped firmly in the palm of one hand, and two wires lead to a galvanometer through an ordinary dry battery and 6-volt rheostat. Normal moisture of the hand will allow a slight current to pass, so



The rubber arm band and its cloth envelope, and how they are applied to the upper arm

the rheostat is adjusted until the galvanometer needle rests at zero. You are then ready to shoot questions at the subject. The meter will remain unmoved until the subject tells a lie, when his perspiration glands will immediately become more active, allowing more current to pass through the electrode. Instantly the galvanometer needle will swing around, and with this visible evidence before him he will be forced to confess that he was fibbing about the answer to your last question.

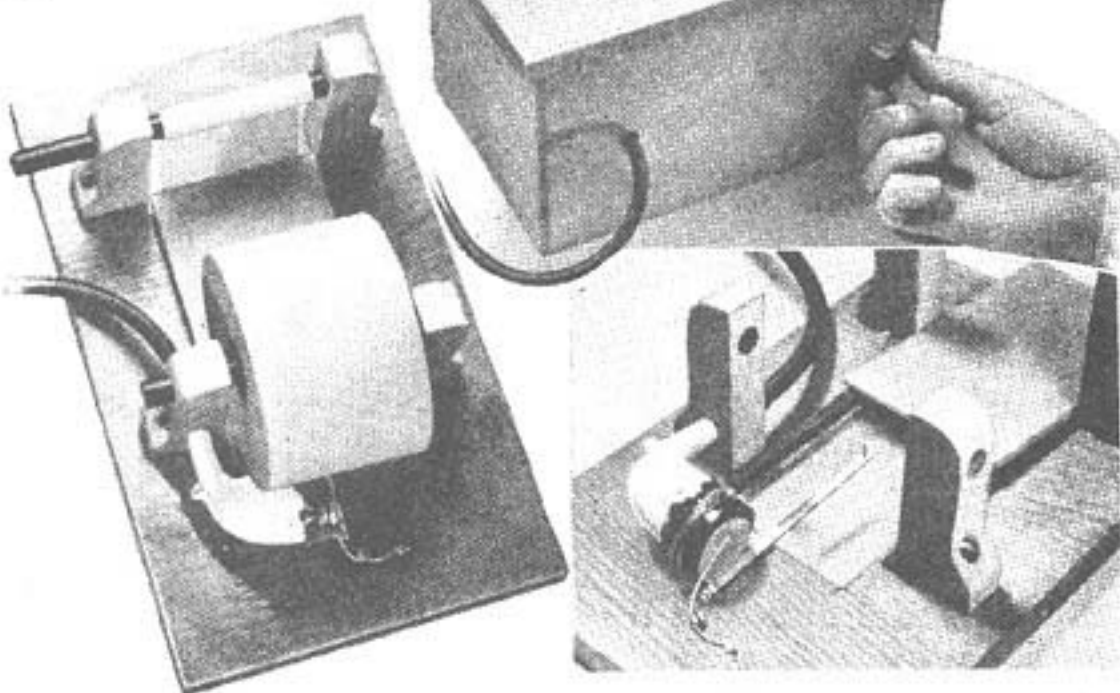


As the blood pressure varies, the recorder makes a diagram like this on the paper tape

You can make the galvanometer from a good compass by wrapping a hundred or more turns of fine enameled wire (such as No. 40 from the secondary of an old spark coil) around it, on the same plane as the needle. Connect the ends to a piece of lamp cord, wiring the cir-

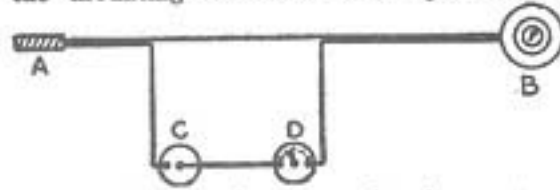
PULSE-BEAT RECORDER

The indicator hand is moved by air pressure from a rubber diaphragm stretched over a pipe under the box cover



cuit as shown in the diagram. Test it by turning the compass until the needle is parallel with the coil; then passing a slight current through the wire should deflect the needle so that it is at right angles to its former position.

In order to make the apparatus appear more complicated and mysterious, the author used the mounting illustrated in a photograph



Wiring diagram for the psychogalvanometer type of detector. A is the hand electrode, B the sensitive galvanometer, C the dry cell or cells, and D a 6-volt type of toy rheostat

at the opening of this article. This is merely three wooden disks glued together and varnished, the meter being set in the upper one. Plain copper wire was wound around the top disk for the sake of appearances, although it has nothing to do with operation of the meter.

The hand electrode is a 1/2-in. wood dowel with two enameled copper wires wound, parallel to each other, around the outside. The enamel was then scraped from the outside, leaving the wires insulated from each other but allowing them to be "shorted" by contact with a moist surface.

To keep the sensitivity of this type of lie detector at the highest point, the hand holding the electrode should be wiped with a handkerchief occasionally and the rheostat adjusted each time this is done.



Handy Workshop Forge Made From Blow Torch

FEW farm or home workshops are provided with a forge, but when the occasion arises where light welding is necessary, a practical little forge may be improvised from a blow-torch. A short piece of gas-pipe provided with an elbow is inserted into a pan partially filled with sand as shown at the left. Blacksmith's coal is heaped over and around the opening of the elbow. Mount the blow-torch on a board, and with a support tilt the torch so as to direct the flame into the gaspipe. This forge will provide sufficient heat for most any welding job.—G. E. Hendrickson.

Cheap Fuel From Waste, Oil Paper

A SLOW burning and very hot fireplace fuel can be had for nothing by utilizing crankcase oil and old newspapers. The papers are folded flat, about nine by twelve inches, and a number of them bound together with baling wire. The blocks are then soaked several hours in a tubful of waste oil, after which they are hung up and drained. They should be stored outside, under cover, and stacked with blocks between to permit air circulation and prevent overheating and the hazard of spontaneous combustion. One block will burn for an hour or two, giving off a good deal of heat at practically no expense.—Bill Crothers.





If either 32-volt or 110-volt direct current is available, nothing more is needed for operating a plating outfit than a lamp bank to regulate the current

Current for ELECTROPLATING

By Kendall Ford

Popular Science 1936

HOW can I obtain the right kind of current for electroplating at home?" is a question repeatedly asked by readers. Evidently there are thousands of home workers who would like to do electroplating, but hesitate because they think that the process requires some special type of current from a complicated power supply. This is a mistaken notion. While it is true that electroplating does require low-voltage, direct current, the necessary apparatus for producing it can be set up without difficulty by any experimenter. A number of ways of doing so will be described in this and a following article.

It is not necessary to go deeply into the theory and methods of electroplating, because the subject has been covered repeatedly in the past, and the necessary information is available in many books. In brief, a thin layer of one metal is de-

posited upon another metal by placing the metal to be deposited, called the "anode," and the object to be plated, known as the "cathode," in a suitable solution. Metallic salts for the more common varieties of plating, such as nickel, gold, and silver, may be purchased ready for use from dealers in electroplating supplies, or the solutions for any type of plating may be readily mixed according to the instructions to be found in any standard handbook of formulas.

When the positive pole of a direct-current source is connected to the anode and the negative pole to the cathode, the cur-

rent flowing through the solution will cause a coating of the anode material to be deposited on the cathode, or object being plated. The current required to plate 1 sq. ft. of metal varies from 1 to 12 amperes, depending upon the plating metal and the solution.

Since the resistance of the solution between the anode and the cathode is quite low, some means must be provided to keep the current at the correct level for the object being plated. Where

a bank of lamps is used, varying the number of lamps in the circuit will control the amount of current. If the current supply is from a low-voltage source, such as a generator, storage battery, or transformer, a small rheostat should be used to control the current.

When 32-volt or 110-volt direct current is available, the arrangement shown in Fig. 1 is both simple and effective. The lamp bank consists of several lamps, the size of which depends upon the current required. For plating small objects, the lamps should be of 5- or 10-watt size so that a fine degree of regulation may be obtained. To determine the polarity of the supply line, place the two leads that go to the plating tank in a solution of salt water, and small bubbles will rise from the negative lead.

If small lamps are not obtainable, an old radio rheostat, from 6 to 10 ohms, placed in series with the larger lamps will help to control the current.

The set-up in Fig. 2, using a storage battery, a rheostat, and a voltmeter, makes a satisfactory power plant for electroplating. The rheostat should have a resistance of from 2 to 6 ohms and may be salvaged from an old radio. The voltmeter should have a range of 0 to 6 volts, direct current.

While a voltmeter is essential for fine work, if one is unobtainable the correct amount of current flowing may be determined approximately by observation when the object to be plated is first placed in the solution. If the object turns dark or black immediately, the current is too high and must be reduced. If the object is not completely covered with a thin coating of the anode material within one minute after being placed in the solution, the current should be increased.

If one of the leads from the storage battery is equipped with a battery clamp,

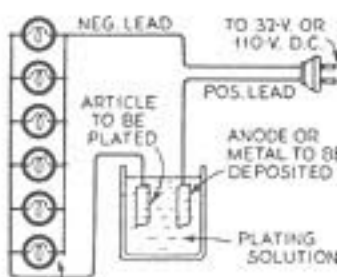


Fig. 1

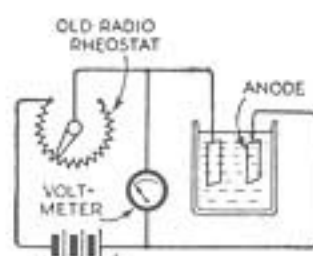


Fig. 2

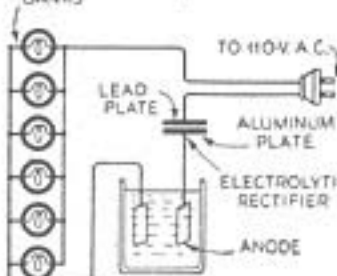


Fig. 3

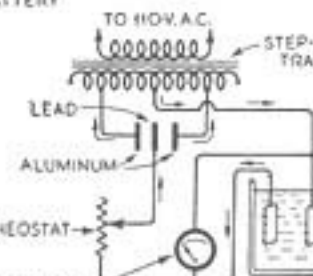


Fig. 4

A CHOICE OF HOOK-UPS

The storage battery and lamp-bank diagram is given in Fig. 1; battery, rheostat, and voltmeter in Fig. 2; various rectifier circuits in Figs. 3, 4, and 5; and an explanation of alternating, half-rectified, and completely rectified current in Figs. 6, 7, and 8

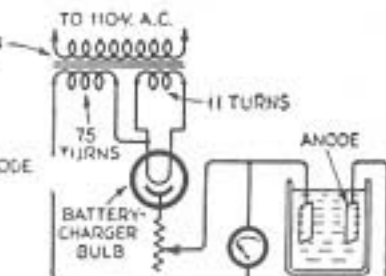


Fig. 5

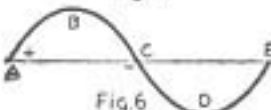


Fig. 6

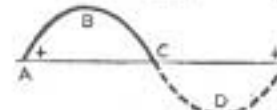


Fig. 7

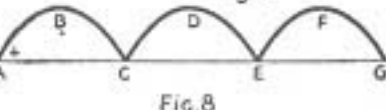
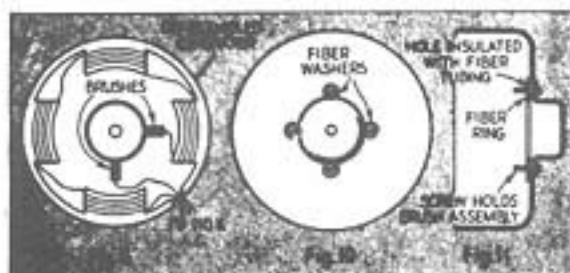
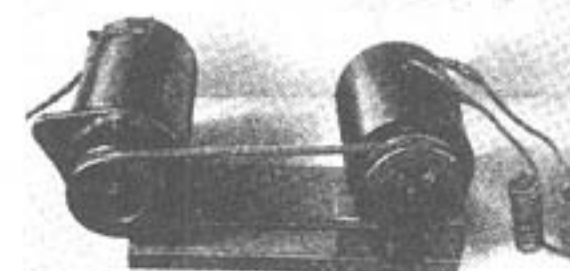


Fig. 8



A 110-volt motor may be made from a discarded automobile generator by the simple changes shown in the diagrams and then used to drive another generator, as illustrated in the photo. Such a motor-generator set supplies up to 15 or 20 amperes

further regulation may be obtained by using one, two, or three cells of the storage battery. To avoid confusion over the amount of current being used and the voltage indicated on the voltmeter, it should be remembered that the voltmeter readings will vary directly with the amount of current flowing between the anode and cathode. Directions for electroplating generally specify the voltage at which the work should be done, the current automatically being correct for that particular voltage.

Where a considerable amount of current is required for plating large areas of metal, a salvaged automobile generator is recommended. When driven by a suitable motor, these generators are capable of delivering a current up to 15 or 20 amperes, which is more than sufficient for the average experimenter's needs. If a driving motor is not available, an excellent motor for the purpose can be made from another automobile generator. In selecting the generators, make certain that they are in good condition, particularly the commutators and bearings.

Practically any type of automobile generator may be converted into a motor by the following method. The drawings (Figs. 9, 10, and 11) illustrate the Ford model-T type because it still seems to be the kind easiest and cheapest to obtain. The same general changes in the generator will be required, regardless of the make, so the experimenter should have no difficulty in applying the instructions to any particular type he is able to obtain.

Remove the brush-holder ring from the current are known, it is an easy matter to calculate the resistance of the rheostat. The plating voltage is subtracted from the supply voltage, and the remainder divided by the required current in amperes. The result will be the value of the resistance in ohms. For example, a plating tank requiring 3.5 volts and 5 amperes is connected to a generator delivering 6 volts.

Subtract 3.5 volts from 6 volts and divide by 5, which gives 0.5 ohms as the resistance of the required rheostat. Actually, it would be better to select a rheostat with a range from 0 to 2 ohms so that it could also be used to plate articles requiring less or greater amounts of current.

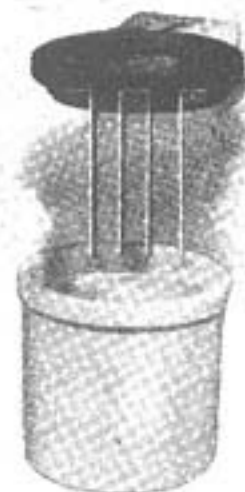
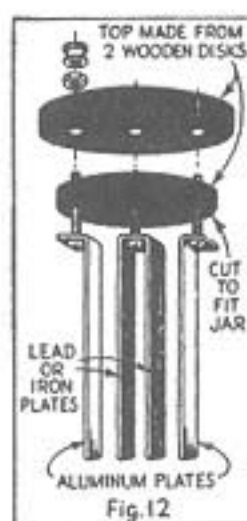
For the purpose of calculating rheostat sizes, the approximate current densities per square foot of surface for the following plating materials will be found suitable for home workshop use:

Chromium	5 to 10 amperes
Copper	6 to 12 "
Nickel	4 "
Brass	6 to 8 "
Bronze	6 to 8 "
Silver	2 "
Gold	1 1/2 "

When 110-volt alternating current is available, a simple electroplating current may be obtained by using a bank of lamps and an electrolytic rectifier, as shown in Fig. 3. If more efficiency is desired and a greater current output required, the arrangement of Fig. 4 is recommended. This consists of a

step-down transformer, a full-wave electrolytic rectifier, a voltmeter, and a suitable rheostat.

A full-wave electrolytic rectifier is constructed by securing two strips of aluminum and two strips of iron or lead to a wooden jar top (Fig. 12). The jar selected should be of glass, porcelain, or stone, and must have a capacity of 2 qt. for each ampere that passes through it. No sizes of the metal strips need be given other than that each should have an area of approximately 15 sq. in. to an ampere. Secure the metal strips to the wood with binding posts. Before assembling the top, paint it with asphaltum or acid-proof paint. Lead is preferred for the inside plates, but if not obtainable, iron will serve equally



SIMPLE ELECTROLYTIC RECTIFIER

To make this full-wave rectifier, two strips of aluminum and two of iron or lead are fastened to a wooden jar top. Before assembly, the top must be treated with acid-proof paint

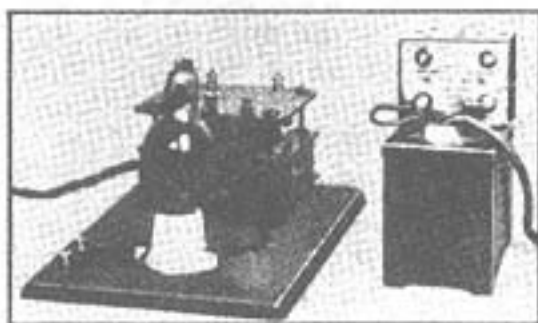
REASSEMBLE the generator and connect as shown in Fig. 9. One end of the field connects to a line wire, the other end to a brush, and the remaining brush lead to the remaining line wire. The brushes should be exactly 90 deg. apart. Since the leads from the remodeled generator are subject to considerable vibration, it is advisable to attach flexible wires to the brush and field leads that connect to the line wires.

The motor may be connected to the generator with a flexible coupling or by means of the original driving pulleys and a belt. Either alternating or direct current, 110 volts, will serve as the supply. The direction of rotation may be changed by merely interchanging the two wires that connect to the brushes. The generator is connected to the plating circuit as shown at Fig. 2, with the generator replacing the storage battery.

A salvaged radio rheostat having a resistance of from 6 or 10 ohms will serve to regulate the current if only small articles are being plated. If several amperes are required, it will be necessary to provide a rheostat large enough to carry the current without overheating.

When the plating voltage and required

Prepare a saturated solution of water and ammonium phosphate, or water and borax.



Discarded chargers of the type formerly used for radio batteries are excellent for plating

well. If iron plates are used, it is advisable to lift the cover and plates from the solution when not in use.

end bell, and the third or smaller brush and its holder from the brush ring. Enlarge the screw holes in the end bell and insulate with fiber tubing (Fig. 11). Make four fiber washers to insulate the heads of the brush-holder retaining screws from the end bell as shown in Figs. 10 and 11. Cut a fiber ring to insulate the brush-holder ring from the end bell. The procedure outlined may vary with different types of generators, but the main purpose is to insulate the brush holder assembly from any part of the generator frame.

In mixing the solution, proceed slowly, dissolving a little of the ammonium phosphate or borax at a time until the water will absorb no more. Fill the jar to within 2 in. of the top with the solution and set the wooden top in place.

Before using the rectifier it will be necessary to "form" the plates by connecting a 110-volt A.C. line to the posts attached to the aluminum strips. A 60-watt lamp must be connected in series with one of the line wires. The lamp will burn brightly at first, then gradually grow dimmer until there is a barely perceptible glow. At that point the rectifier is ready for use.

The half-wave rectifier shown in the circuit of Fig. 3 is constructed similarly to the full-wave rectifier with the exception that there is only one aluminum plate and one lead or iron plate. The rectifier is "formed" by the same method outlined for the full-wave rectifier, the connections being made to the aluminum and lead or iron terminal posts.

In order to understand the principle of the electrolytic rectifier, it is necessary to remember that alternating current first flows in one direction through a circuit, then reverses and flows in the opposite direction. As indicated in Fig. 6, the current rises from zero potential at A to a maximum at point B, where it diminishes to zero potential at point C. Then it begins to flow in the opposite direction, rises to maximum potential at point D, and diminishes to zero potential at point E. This complete operation is called a cycle, and the number occurring in one second, usually 50 or 60, is called the "frequency."

Since in electroplating the current must flow in one direction to cause the anode material to be deposited on the object being plated, it can be seen that if we attempt to plate with alternating current, both the plating metal and the object to be plated will alternately act as the anode. Metal deposited from the original anode during half of the cycle will be carried

back to it during the last half of the cycle,

therefore none will be deposited. If a strip of aluminum and a strip of iron or lead are placed in a solution of ammonium phosphate or borax and connected to an alternating current line through a lamp or resistance, a film of oxide will form on the aluminum strip which will prevent the current from leaving the strip, yet allow it enter from an opposite direction. This principle is used in the full-



SWITCHBOARD FOR PLATING

Current from a storage battery may be regulated by means of a rheostat and voltmeter, which are best mounted on a convenient panel. A back view of the panel is shown above, and the complete set-up for plating at the left

wave rectifier.

The half-wave rectifier, consisting of a single aluminum plate and one lead or iron plate, is so called because it will rectify only half of the cycle as in Fig. 7.

When the full-wave rectifier is used in conjunction with a center-tapped, step-down transformer, both halves of the cycle are rectified, resulting in a pulsating direct current similar to Fig. 8. The current flows alternately from the lead plate to one of the aluminum plates, then from the lead plate to the other aluminum plate. From each aluminum plate the current flows through the transformer secondary coils in an opposite direction to the center tap of the trans-

former, where it flows out to the anode of the plating tank in one direction (Fig. 4).

Other rectifiers suitable for electroplating are the types used for charging radio batteries before the all-electric set made its debut. Among these are the kind that uses a gaseous bulb containing a plate and a filament (Fig. 5); and the copper-oxide type, which consists of a series of specially treated copper plates.

A transformer for use with either the electrolytic rectifier (Fig. 4) or the battery-charger type (Fig. 5) should have two secondary windings, each delivering 6, 8, and 10 volts. Detailed instructions for making a transformer will be given next month.

HOW TO WIND A Step-Down Transformer FOR ELECTROPLATING AND OTHER PURPOSES

ONE excellent way to adapt ordinary 110-volt alternating current for electroplating, which requires low-voltage direct current, is to use a homemade step-down transformer in conjunction with a rectifier, as explained last month (P. S. M., Nov. '36, p. 62).

The transformer shown in the accompanying illustrations was especially de-

By Kendall Ford

Popular Science 1937

signed to operate in conjunction with an electrolytic rectifier in a circuit such as that marked Fig. 4 in the previous article, but with slight changes it may be used with a discarded radio battery charging rectifier. It is also a good general utility transformer for ordinary purposes because it has a range of from 2 to 20 volts in 2-volt steps.

For use with an electrolytic rectifier, a transformer should have two secondary windings, each delivering 6, 8, and 10 volts. This makes it possible to adjust the voltage over an extremely wide range with a single rheostat.

The first operation in building the transformer is to cut a sufficient number of transformer laminations to make a stack of each size $2\frac{1}{4}$ in. high when pressed tightly together. Suitable laminations can usually be obtained from burnt-out transformers, but if these are not obtainable, No. 26 gauge stove pipe iron may be substituted. Drive a number of nails into a board to make a form for stacking the transformer core, and place a strip of tape across each end to hold the laminations temporarily in place,

as illustrated in a photograph. The nail form should be $4\frac{7}{8}$ in. long. Begin stacking the core sections by placing one of the longer laminations against one end of the form, and another long lamination against the opposite end of the form. Continue to stack the long core laminations alternately until half of the total number is used.

Secure the two strips of tape around the assembled core section and carefully remove it from the stacking form. Place the core

Wind 550 turns of No. 22 D.C.C. (double cotton-covered) magnet wire on a wood form to serve as the primary winding. A suitable winding form is shown in Fig. 1. This consists of a wood block $1\frac{1}{8}$ by $1\frac{1}{8}$ by $2\frac{1}{4}$ in., and two thin wood ends, $2\frac{1}{8}$ by $2\frac{1}{8}$ in., held together by a crank-shaped threaded rod.

Saw slots from the outer corners, extending toward the center and into the center block to provide for tie wires. Place about 10 in. of any small size wire in each slot

in the wood center block and allow them to extend beyond the end blocks. Wrap several layers of thin cardboard around the center block, and proceed to wind the coil.

A small piece of pipe placed in a vise will support the form while the coil is being wound. When 550 turns have been wound, bring the ends of the tie wires through the slots in the end pieces and twist them together. Remove the coil carefully from the form and cover with shellac or melted paraffin to serve as a binder. When the binder has hardened, attach a piece of lamp cord to the coil ends, and tape the coil with cotton or friction tape.

The secondary coils are wound directly on one of the taped core sections. Place a strip of friction tape along the core and fold one end back around

the starting lead. The following turn of wire will pass over the end of the tape and hold the coil firmly in place. For the transformer having adjustable voltages, wind 11 turns of No. 16 D.C.C. magnet wire on the core section and bring out a twisted lead, as shown in Fig. 2. Wind 11 more turns, bring out another twisted lead, then wind on 33 turns. The end of this 33-turn coil, when twisted with the start of the next coil, will serve as the center tap of the transformer. In winding the remainder of the secondary coil, 33 more turns are required, then two more coils of 11 turns each, with a twisted lead brought out from the end of the 11-turn coil next to the second 33-turn coil.

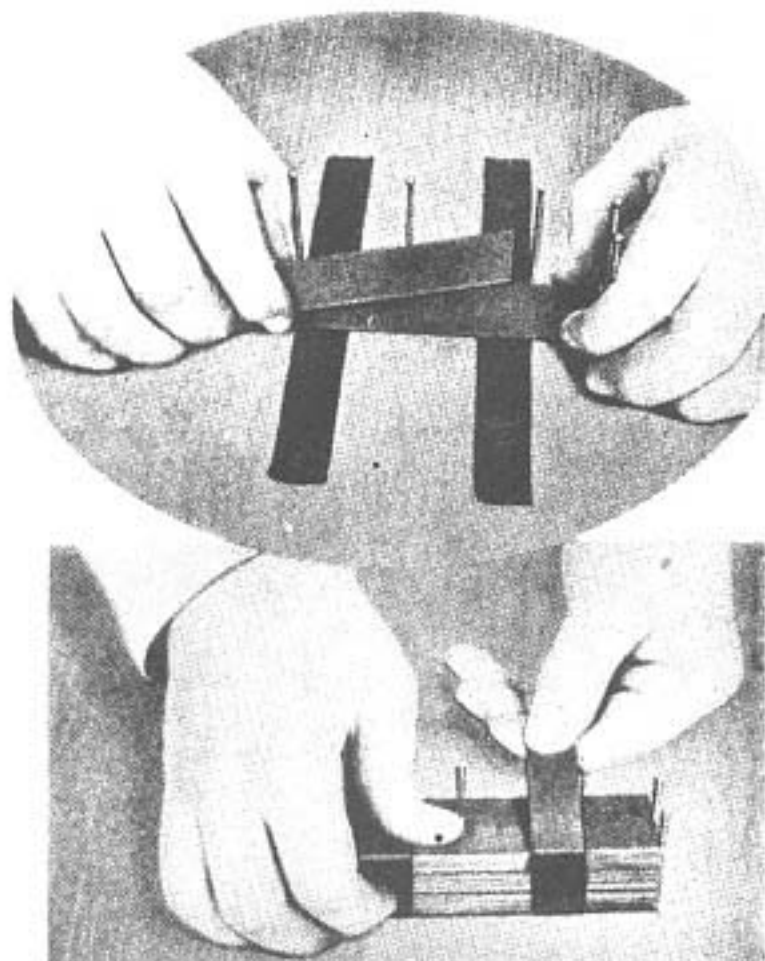
When the winding is completed, there should be two single leads and five double leads extending from the winding. Each layer of winding should be held in place with a strip of

section in a vise with about 1 in. of the solid portion of the core extending beyond the vise and wrap this solid portion tightly with friction tape. Continue to move outward from the vise and tape about $\frac{3}{4}$ in. at a time until the whole solid portion of the core section is taped. Wrap a second layer of tape around the core section and coat with shellac. Proceed with the remaining long laminations as above, making two taped sections in all.

Placing the end laminations in the core



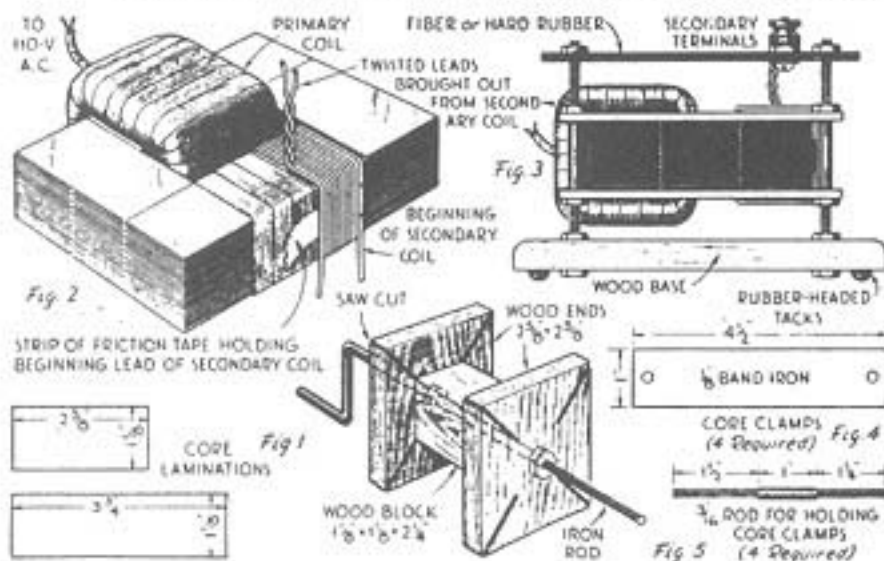
A taped section of the transformer core appears above. On this the secondary winding is started as shown at the right



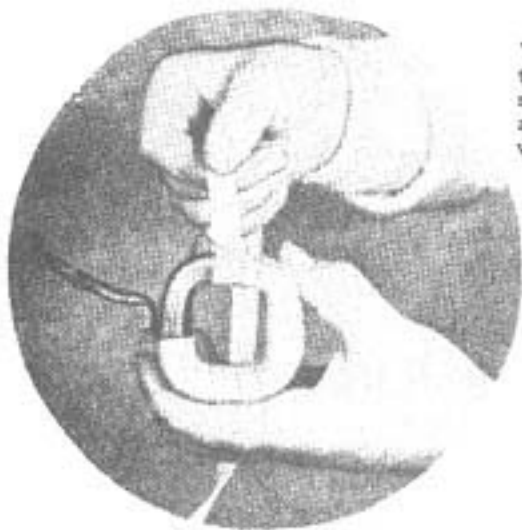
The method of stacking the laminations is shown in the oval. They are bound with tape before being removed from the form

tape, as was done with the starting layer. It is advisable to tape the twisted leads where they pass between the turns of wire to prevent a possible short circuit at that point. Tape the winding, place the primary coil over the other taped core section, and insert the short laminations in place, one half of the total number going on each side. The short laminations are alternately placed in the spaces between the long laminations until all spaces are filled (Figs. 2 and 3).

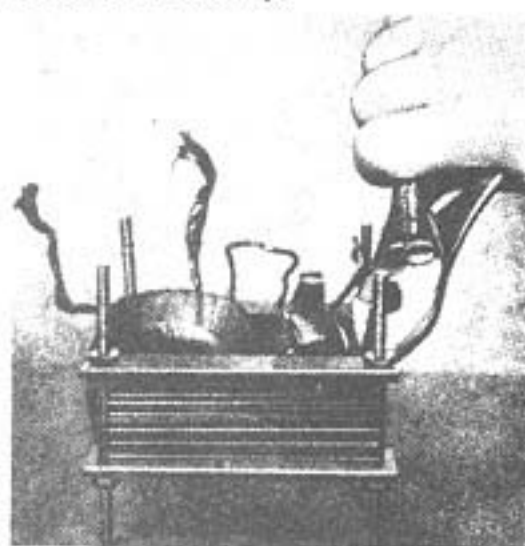
Cut and drill four end clamps (Fig. 4) and provide threaded rods (Fig. 5) to hold them in place. Place the clamps on the core and mount the transformer as shown in Fig. 3. Provide seven terminal screws and connect the secondary terminals to the screws. Mark the terminals to indicate the voltage of each.



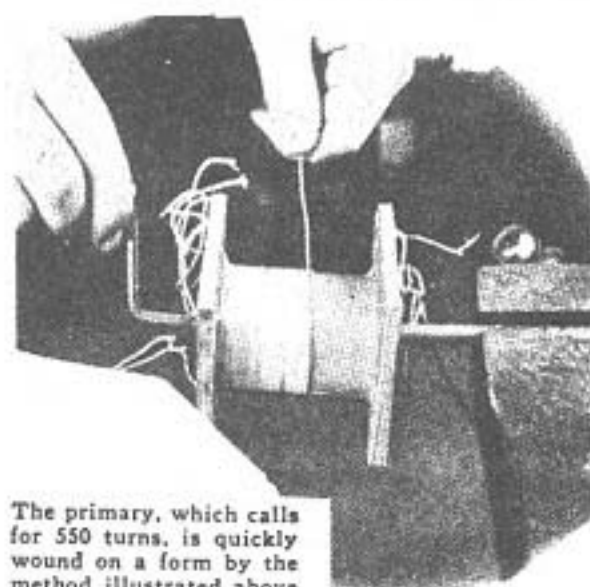
Core laminations, winding form for the primary coil, a sketch showing how secondary leads are brought out, and method of mounting the whole



When removed from the form, the winding is covered with shellac or melted paraffin and bound, as at the left, with cotton or friction tape



Tightening the end clamps on the core, after which it is necessary to add terminal screws



The primary, which calls for 550 turns, is quickly wound on a form by the method illustrated above

When not used in conjunction with the rectifier, the transformer makes an excellent general utility transformer delivering from 2 to 20 volts in steps of 2 volts. Approximately $\frac{3}{4}$ lb. of wire will be required for the primary coil, and $\frac{1}{2}$ lb. for the secondary coil.

If it is desired to use the transformer in conjunction with a small size, or 2-ampere battery-charger bulb, it will be necessary to

wind a different number of turns on the secondary coil. Start the winding as outlined

above and wind 75 turns of No. 18 D.C.C. magnet wire on the core. Make a twisted lead and wind 11 additional turns of No. 14 D.C.C. magnet wire. The larger wire connects to the filament circuit of the battery-charger bulb, as shown last month. In winding both of the transformers just described, make certain that all of the secondary coils are wound in the same direction.

SHRINKING GLUE CHIPS GLASS

Popular Science 1931



applied with a brush. The glue sinks into the tiny depressions in the glass. As it dries, it shrinks. So great is the glue's tenacity that it pulls off chips of glass in an irregular frosted pattern that diffuses the light but does not leave the glass transparent. When the glue and chips are washed off, the pane is ready for the market.



At upper left, a coat of glue is applied to clear glass. At left, a pane of glass as it looks after it is chipped by shrinking glue.

FROSTED glass for office partitions and doors is now made by using the amazing pulling power of shrinking glue. First a sheet of glass as smooth and clear as a window pane is lightly sand-blasted. Then a strong adhesive, such as animal glue, is

Modern Mechanics 1932

Lawn Sprinkler From Gas Burner

THOSE burners found in old gas stoves lying around junkyards can be pressed into service as garden sprinklers. The pipe which leads to the burner proper is attached to the hose by means of a ferrule. When the burner is laid flat on the lawn it spreads the water over a surprisingly wide area. If the points of the burner are each bent down slightly this area will be increased considerably.—Wayne Wheeler.



SOLDER COAT PROTECTS METAL FROM RUST



A USEFUL method of protecting any metal object except aluminum from rust is to give it a coating of solder or zinc. The solder or zinc can be heated in an iron ladle, and the part to be coated, after being thoroughly cleaned, is thrust into it. Several particles of zinc chloride or ammonium chloride (sal ammoniac) laid on top of the molten metal will serve as a flux. The object can also be dipped into "killed" acid or a solution of zinc chloride before it is thrust into the solder. After taking it from the molten bath, throw the object on the bench or floor so the excess metal will be removed by the impact.—R. B. W.

FOOD AND SURVIVAL

by Kurt Saxon



RAISING PIGEONS FOR FOOD AND SECURITY

By Fred Bilello

Most of us see the world of the future as one of scattered, isolated settlements and communities.

One matter of importance in this life will be communication with other areas. Radio, T.V., and telephone service may not be available, and unless you have a C.B. and the energy to power it, you will be oblivious to what is happening around you. Also, you may be in need of medical assistance, or perhaps you are being attacked and need help. Distances as short as a few miles may not be easily negotiated.

One way to overcome this lack is to raise homing pigeons. These creatures require little care and can easily find their way home from miles away. Messages are carried in small aluminum tubes fastened to a leg, and can be bought at most feed and hobby shops.

Pigeons are found everywhere and can be caught with a box trap. Some are so tame you can catch them with your hands.

Concentrate on the ones that have bands on their legs. If the band is made of rubber, the bird was bred to race, and probably got lost in a storm. Forget the ones without bands. Most of them are clunkers, but if you see a big, healthy looking one, get him.

Once you have your flock, keep them in your coop and breed them. You can make a coop from scrap wood and tarpaper. It should also have a screened-in porch where they can sun themselves and get to know the surrounding area. The coop should also have a wide board, high off the ground, where they can land. To enter the coop, (the birds, that is), cut a square out of the side about 7" high and 12" wide, flush with the landing board. Insert a series of metal bars made from coat hangers that will enable them to push through and get in. There should be a

The cost of food has been rising several percentage points yearly for the past several years. This year it is supposed to rise as high as 16% over last year. Last year's drouth, this year's floods, more people, less farmland, farmers' strikes and many other factors will soon make food the greatest expense in the family budget.

Liberal economists, seeking to avert panic, say "So what if the family food bill approaches 30 to 40% of the average American's budget? Some of the world's people pay as high as 80% of their income for food."

Such a stupid rationalization would only comfort a fool. Higher food costs mean an all-around lowering of the living standard. Unlike inflation on cars, clothing or other commodities, which can be taken care of and saved, recycled, etc., money spent on food is literally money down the drain. So if you spend 40% of your pay check on food, rather than 15% as of ten years ago, you have that much less to spend on commodities which can be saved.

The higher the percentage of its income a nation spends on food, the lower its overall standard of living. The lower its standard of living, the lower its reserves for research and development, defence, public works and future planning. Rising food prices will soon lower the American standard of living to that of Mexico and finally Russia, then Africa, then India, then goodbye U.S.A.

As far back as 1972 I wrote one of the first survival food books, titled HOW TO CUT YOUR FOOD BILL BY HALF OR MORE-CITY SURVIVAL DURING THE FAMINE TO COME. I knew of the changing weather patterns even then and realized food prices were going to rise dramatically. In 1973 came the Russian Wheat Deal which wiped out the U.S. grain surplus and sent most U.S. food prices up about 100% in that year. The official estimates of the rise was only about 18% but for a time, most staples did go up about 100%. In time they dropped, as the effects of the wheat deal were lessened by more cropland being taken out of the soil bank.

Now they are up again and going higher, this time without the help of the Russians. Also, the U.S. has little, if any, land lying fallow as in 1972.

In 1972 there were many books out on cheaper foods but they were not survival food books. They were more health food books than books meant for food economy. They were sound enough in their information but the emphasis was on health, rather than economy. They were also written mainly by health nuts who had no interest in economy, anyway. Food prices in health food stores are far higher than in the supermarkets and such books were of more benefit to the health of the health food store owners than the buyers of the books.

As books on food economy began to come out after the food price rises of the early '70s, most of them were trash. They ranged from hippy books on scrounging from behind grocery stores to those by befuddled housewives telling how to save pennies in the supermarket.

Both the books on scrounging and in taking advantage of supermarket bargains were, and are, evading the issue of the Survivalists' independence from the Establishment. They are as unrealistic as a parasite who says he's giving up on the Establishment, quits his job and goes on welfare. The scrounger, the supermarket penny pincher and the welfare recipient alike, are hopelessly locked into the Establishment and will fall with it.

The main idea is to become independent of an increasingly unworkable system. This can only be achieved by cutting out the middleman; the food processor. The recent farmers' demonstrations show that the growers get only a small percentage of the food dollar. Fully 40% of the price of food goes to labor paid by the food processors. Another percentage goes for packaging, advertising, trucking and grocery store overhead.

So food, as it is grown on the farm, is still relatively cheap. Your key to lower food prices is to buy it from the growers themselves, or through natural food stores, located in most towns. Foods in these stores are not necessarily

parallel bar at the bottom, on the outside, that will prevent them from getting out.

Once the birds have mated, your home will be their home. Spring is the best time to mate them, but they will mate year round if you let them. Now you can begin their training. If you have the time, don't use it on the birds you caught. The young ones learn fast enough and will be more loyal. They will eat almost anything but prefer grain. You should also keep them supplied with fresh hay and grit. The grit helps them digest the grain. It consists mostly of tiny pebbles and crushed shells, thoroughly washed. It can be cheaply bought.

To train them to come home, start them off by releasing them about a quarter of a mile from the coop, and as they get to know their way around, increase the radius. I also understand that they can be trained to fly at night, but have never experimented this concept. The trick is to keep them in a dark area from when they are born, and only letting them out at night. When feeding the birds, whistle at them. Like Pavlov's dogs, they will become programmed to where they will link food to your whistling. You should only let the birds out when they are a little hungry, so you can call the entire flock back in seconds with a whistle.

During the training, you will be able to pick out your best birds. They will come back first. Stragglers who return days or weeks later will make an excellent addition to your menu.

Anyone who has plans to set himself up as a local Vigilante should think about using this communications system. As part of your services, you can lease the birds to neighbors in exchange for their services. If you do not want to be a Vigilante, get other survivalists to raise their own pigeons. Then you can swap birds for mutual protection. Use at least three birds each. That way you can be pretty sure at least one will get through with the message. Be sure that you don't keep them too long, or they may forget their way home. Every so often, release them, and swap three more for their tour of duty. If your refuges are isolated, this will be an excellent excuse to socialize. Also, don't mix your friend's birds with your own. They may mate and not want to return.

To give you an idea as to their potential, homing pigeons are bred to enter races that span hundreds of miles. So for your purposes, these birds are all you need for a fast form of communication.

One final suggestion is to collect their droppings. It has a high nitrate content and should be used for fertilizer and in the eventual manufacturing of explosives.

cheaper than that in the supermarkets, but they take orders for foods in bulk at considerably reduced prices.

In planning to economize on food, you should take a drive around the outskirts of your town or city and meet some farmers. Roadside stands, selling farm produce are also bargain places. People working there are usually families of local farmers and they are happy to sell you vegetables, not only by the pound, but by the bushel, the case and various other sizes, at a fraction of the cost you would pay at the supermarket.

When checking into the buying of farm produce, check also on the seasons when it is best to go hunting for particular products. You can then plan on getting produce, and even grains and freshly slaughtered meat by the truckload. You can take them home and can them or otherwise store and preserve them and at little cost, compared to what you pay the food processors.

My food book, page 190 of SURVIVOR Vol. 1 was written mainly for food economy and has been expanded to cover canning, drying, meat preserving, etc. It is a complete manual on home food processing.

The problem is, it's a poor seller to Survivalists. Most of my readers seem fixated on buying weapons and tools and seem to think food books are for women. This is stupid. Food economy is far more important to the Survivalist than anything else. The more you pay for food, the less survival equipment you can afford.

I remember subscribing to the BLACK PANTHER, the main publication for black militancy. Each issue was full of threats of violence against the "pigs". Page after page was devoted to buying weapons and ammo, their care and use. But there was no mention of stocking up on foods.

I remember, during the Watts Riots of 1964, the ghetto area of Los Angeles was being systematically destroyed by rioters and looters. After four days the rioting stopped. This was because the mailmen refused to go through the battle lines to deliver the welfare checks. The food stores had been looted and burned and the rioters were hungry. With a supply of food, the rioting could have gone on for weeks. But the cause for its ending was so obvious to the officials that they wrote the blacks off as just a bunch of belligerent dummies with short fuses and no staying power and consequently unworthy of further concern.

The same pattern was repeated in Detroit and several other riot-torn areas. It was so predicatable that later riots were simply contained by the authorities, who knew that hunger would finally put an end to it and the dummies would then settle down in their burnt out areas. Then there would be hardly any rebuilding, fewer jobs, less business, more welfare and so what?

Maybe you think you're smarter and can use your guns to get food. But when it hits the fan, the supermarkets will be cleared out in hours. Then, those provident ones who have a good supply of food will shoot you on sight. Common sense should tell you that if you will have to fight for the food you get, you won't live long at all.

I converted to unprocessed foods years ago and, although you may prefer dehydrated foods, I chose mainly grains and fresh farm produce. It's a matter of individual preference but you should familiarize yourself with various approaches to survival foods.

The only bread I eat is a kind I invented. It is one third corn, one third hard red wheat and one third rye, ground in a hand grinder bought at any health or natural food store. From the natural food store I bought 50-lbs. each of the hard red wheat for \$12.15; corn, \$10.00; rye, \$11.25. Total \$33.30. I also bought a pound of baking powder, without aluminum, for 80 cents.

To bake the bread, I ground and mixed three equal portions of two pounds each of the wheat corn and rye. You wouldn't want to grind all your supply at once as it stores better as whole grains.

The recipe is 2 cups of flour (10 oz.), 3 level tsp baking powder, 1 level tsp salt, 2 tbs melted cooking oil, bacon grease or what have you and one large egg. First pour 1½ cups of water into the flour. Then mix in the egg and salt.

Oxford Sausages.

— To each pound of lean pork allow one pound of lean veal, one pound of fat, part pork and part veal. Chop and beat well with a lard-beater. Allow one pound of bread-crumbs, thyme, a little parsley; an ounce of sage leaves, chopped very small; two heads of leeks, or a little garlic, or shalot, chopped very fine; salt, pepper, and nutmeg. To each pound allow one egg, the yolks and whites separately; beat both well, mix in the yolks, and as much of the whites as is necessary to moisten the bread. Then make the sausages in the usual way.

Worcester Sausages

are made of beef, &c.; add allspice, and any other spices and herbs you may choose.

Mix well and then mix in the oil. Preheat a large, greased frying pan and then quickly mix in the baking powder and pour the mix into the pan. Jostle the pan so the mix settles evenly.

Then turn the fire down to where it doesn't touch the bottom of the pan and cover it and let it alone for 15 minutes. Then turn the bread over and let it cook 15 minutes more without the cover. If you have the heat adjusted right you will have over a pound of the most tasty and nutritious bread possible.

My test batch weighed 21 oz. and cost 21 cents for the ingredients. This was a coincidence as it might be an ounce more or less different. At any rate, it can be considered a cent an ounce as compared to 3½ cents an ounce for 24-oz. of Roman Meal and another popular wholewheat bread, which sells for 83 cents for a pound and a half loaf.

Anyone can make this bread. You don't have to buy the grain in 50 lb. bags. You can buy a test batch for 27 cents a lb. for wheat; 23 cents corn and 25 cents rye. A quarter of a loaf of this bread eaten for breakfast along with your eggs and bacon or whatever, will give you a burst of energy which will help you to work like a horse for hours. You'll be surprised. It'll also be a great backpacking food as it dries to a light hardtack which is energy-packed as well as tasty and lasts for months. Just slice the loaves in half and dry naturally.

This bread, fresh, is also delicious. Its texture is somewhat moist in the middle, like cake, even though it is well done. It is also highly digestible.

Introduce this bread to your family and they will accept it and you will have cut your bread bill by two thirds.

Then there are soybean sprouts. I bought 50-lbs. of soybeans from the natural food store for \$14.50. I put 6-oz. (1 cup) in a gallon jar and soaked them overnight. I put a piece of cheese cloth over the top, held on with a wide rubber band. I emptied the soak water and filled the jar with fresh water and then turned it over and let the beans drain on the side of the kitchen sink. I filled and emptied the jar again that evening and twice daily for about a week, until the bean roots were about four inches long.

At this time I emptied the sprouts into a dish-pan full of water and picked out the live and good sprouts, leaving the hulls and the dead seeds behind. I weighed this batch and found that there were over four times the original six ounces.

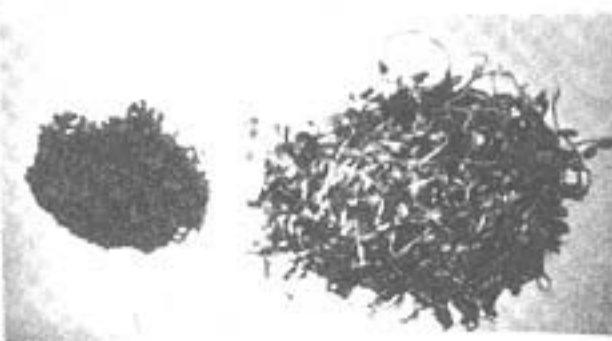
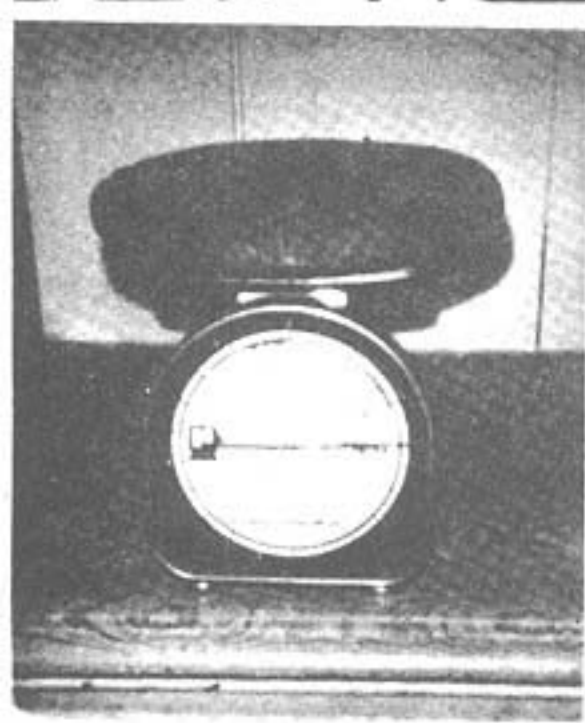
Soybean sprouts are the most nutritious vegetable I know of. Mung bean sprouts are more popular but soybean sprouts are more nutritious. So for 11 cents for 6 oz. of soybeans at \$14.50 per 50 lb bag you get the most nutritious green vegetable for the price of only 8 cents per lb. Try to get a green vegetable for 8 cents a lb at your local supermarket.

Soybean sprouts are cooked for 10 to 20 minutes or can be eaten raw in salads.

As sprouters, I used gallon glass jars. Smaller jars won't do as the sprouts bunch up and mold catches on too well and is harder to flush out. If you can't get gallon-glass jars, use gallon tin cans, painted inside or gallon plastic bleach bottles, cut off at the top.

You can have as many jars, cans or plastic bottles going as you like. This will give your family a steady supply.

I'm sure if you try the above two simple recipes you will begin to save money and get your family enthused about the idea. You might also offer them a family gift to be paid for with part of the savings. That would give them a greater incentive to adapt to different, cheaper foods.



PEMMICAN— THE COMPLETE SURVIVAL FOOD

By Jewell Watson

I first learned about pemmican from an article titled "Power Food" written twenty-five or thirty years ago by Graham L. McGill. To my mind, this is the most complete survival food I know. He says the North American Indians and early explorers knew it as lean, dried buffalo meat and fat. It keeps indefinitely without refrigeration and may be eaten exclusively for as long as a year without producing any undesirable effects on the body. Although for most people the taste for it must be acquired, many people like it when eating it the first time.

McGill says for thousands of years pemmican was the staff of life for the Indians; no other rations were carried on a long hunt. Later fur-trappers and explorers learned of it from them and it became the most important item in their packs. Now it is almost completely forgotten but we need to know about it again as a survival food.

Its nutritional value is high. When it is made properly it contains vitamin C and other essential elements which are necessary for good health. It is a well known fact that groups of explorers on long expeditions often developed scurvy because of the lack of vitamin C in their diets. McGill says that although pemmican was the sole diet of a group of arctic explorers for a period of six months, not one of them suffered from scurvy during this time.

To those of us who are health-minded it is important because it does not contain the nitrates and nitrites which are found in prepared meats. It has not been produced correctly commercially so you must make it yourself to get all the nutritional benefits from it. Also, one may lose excess weight on a diet of it alone. McGill says he lost twenty pounds excess weight in two months on an exclusive diet of it. It also seems to have psychological benefits. His wife said he was calmer and more optimistic.

It cannot be beat for convenience on a back-packing trek in the wilderness. It will keep without refrigeration or salt. On the trail this is important as salt produces thirst and one may be far from water for a time. It needs no cooking or preparation, however, it may be warmed if desired. It is light in a pack. One may carry thirty pounds of it on a thirty-day

HORN OF PLENTY IN YOUR FOOD DRYER

by Kurt Saxon

Drying has been the most common method of food preservation for thousands of years. It is also the simplest and most practical method. It removes most of the weight, enabling one to carry more. Its reduction of bulk saves space. It is also the cheapest, requiring no particular containers, little or no energy and a minimum of labor. It also has an indefinite shelf-life.

Indians sun-dried fish, meat, corn, squash, peppers, etc. My grandmother used the hot attic to dry apple slices and her homemade soap. Sun or attic drying costs nothing. It is best to have a simple frame over food to be dried. Drape cheesecloth over the frame to keep flies off. In an attic you don't need the cheesecloth. But you should have the food laid out on boards suspended by wire from the attic ceiling away from mice.

Prices for dehydrated foods are fantastic. Next time you are at the supermarket compare the prices of dried fruits with fresh. I have several cans of dried vegetables and fruits I bought about five years ago. A one ounce can of freeze-dried green peppers cost \$3.07. Four ounces of freeze-dried potatoes cost \$4.15. Six and one fourth ounces of dehydrated apples cost \$4.35. When you consider how simple the drying process is, it doesn't make much sense to pay others to do it for you.

You may lack an easily accessible attic, yard or roof. Also, maybe your weather is mostly humid or too often cloudy or maybe it's not summer when you have food to be dried. In this case you need a food dehydrator.

There are several on the market. They are all good, since the principle is so simple only a fool would manufacture a poor one.

At the last gun show I attended I bought a five tray Ronco for \$50.00. A three tray unit would have cost \$40.00. Sears, Pennys and Montgomery Wards sell the Ronco for \$90.00 for the five tray unit and \$70.00 for the three tray unit.

You can order the five tray unit for \$50.00 and \$40.00 for the three tray from Don Lewis, Dallco, Inc., 1805 N. Logan, Lincoln, IL 62656 (217) 732-3960 They're cheaper since Lewis is a promoter.

The Ronco is a good unit and pretty and comes with a booklet telling all about how to dry fruits vegetables, meat and fish and even how to make yogurt in it.

If you aren't at all handy, and can afford it, order one.

When I examined my Ronco I saw that its principle was so simple I could make one. I did and tested it with 2 1/2 lbs. of beef for jerky. I divided the beef between the two units and was very

trip and need nothing else. It is so concentrated, a pound a day gives one enough nutrition and energy to do a days work and feel fine.

As to the preparation of pemmican, the Indians cut all the fat from buffalo, moose or any other lean meat; cut the meat into strips and hung it up to dry thoroughly. When it was ready to take down, they melted the buffalo fat over a slow fire, pounded the dried jerky into a powder and added it to the slightly cooled, melted fat. This was pemmican the Indian way.

As I lived in the city at that time I had to find a way to buy meat and fat (suet) that was suitable for pemmican. I found that beef and mutton suet do not turn rancid as do pork and butter but I preferred the taste of beef suet to mutton. Suet is very inexpensive; about ten cents a pound where I live and some markets will often give it to you. I also learned there is a difference in suets. Some of it did not render out as much fat as I needed so I learned to buy what I call the "flaky" kind which melts well.

I tried making pemmican by drying boneless stew meat but I found that most stew meat has too much fat on it and in it. If I cut the fat off I would not have much meat left so I left it on and the meat was too greasy to pound into a powder. Because of this I could not get the ligaments and gristle out of it so I put it into my Vitamix machine, blended it into a pulp and put it in the cooled melted fat. It tastes the same but has more fiber in it than that which is pounded to a powder and so the texture is different. I also believe the Vitamix machine gets so hot, it might destroy the vitamin C. I am going to have to find a place I can buy a cut of boneless, lean beef. I have occasionally found beef in the markets lean enough to make pemmican but not often. I thought I might try brisket but it is often as fat as any other meat. One is very fortunate to live where he can raise his own beef and dry a part of it.

The drying takes anywhere from a week to a month depending on the climate and the size of the strips. The smaller the strips the quicker it dries, of course. It is better to have it too dry, if that is possible, than not dry enough. It must become as black and hard as it can get. It will mold if it is not dry enough. String it on strong cords (each only long enough to be easy to handle). Nail the cords high up between trees or posts outside if there is plenty of sun and good breeze. Spread the pieces of meat so there is a space between them. It must stay dry so if the climate is damp or unfavorable for drying, it must be dried indoors. I found it easier to dry it indoors than to try to keep it dry outside.

pleased that mine worked better. It was faster and the beef was more uniformly dried than in the Ronco. Much of that in the Ronco had to be rearranged so as to dry completely.

I think just about everyone likes beef jerky and it costs about 50 cents an ounce from the store. I had a little over a pound for \$3.75 or 22 cents an ounce. Jerky is delicious and a couple of ounces nearly makes a meal. It is also more nutritious than cooked beef.

It is very simple to prepare. Get the cheapest beef roast and remove any fat. Cut it across the grain in slabs about 1/4 inch thick. Then cut the slabs into inch-wide strips.

Next, the beef strips have to be soaked in a marinade. This is simple and anyone can make it. Get a bottle of Kikkoman Hawaiian Teriyaki Barbecue Marinade & Sauce or Lawry's Tenderizing Beef Marinade or any other brand of marinade from your supermarket. Buy Liquid Smoke from the same shelf.

Use a bowl large enough to hold all the beef strips and put in four tablespoons of marinade, two tablespoons of Liquid Smoke, two teaspoons of salt, one teaspoon of red pepper and two-thirds of a cup of water. This is enough for about four lbs of meat. Put the strips in the marinade one at a time and make sure each is covered with the mix.

After soaking for 30 minutes or overnight, empty the meat into a sieve and let the excess marinade drain. Then lay the strips around the centers of the trays, barely touching, certainly not overlapping. Leave a four inch circle in the middle of the trays for better heat circulation. In the case of my design, the bare circle prevents the juice from dripping on the lightbulb. The unit shrinks the meat before drying the juice so it does have a tendency to drip.

After three hours, rotate the trays so the bottom one is on top, etc. This will better equalize the drying process. After three more hours the beef should be dry. This is easy to check. Just cut a strip in half at the thickest point. If it is dark clear through, it's done. While still hot it will be limp. But it will stiffen as it cools. Don't be too picky about the three-hour drying time. If you cut the beef slightly thicker or if your unit is of slightly different dimensions it might take a longer or shorter time. But since it costs next to nothing to run, run it however long it takes. You can't hurt jerky.

Drying vegetables is another matter. They're all different but need blanching. To blanch vegetables, cut them in thin slices or dices and then immerse them in boiling water or steam them for two minutes or however long is recommended for that particular vegetable. This not to cook them but to kill any bacteria and it also stops the action of whatever living enzymes they have so they don't change color or lose vitamins.

Drying fruits requires pretreating by dipping in a salt solution, lemon juice, etc., again to

When it was dry I took it down, placed it on a clean dish towel on my cutting board and pounded it with a hammer into a powder. There will be pieces of gristle left which must be separated from the powdered jerky and thrown out. These are too hard to eat.

Before I started pounding the jerky I had cut the suet into small pieces and had it slowly melting on the stove. From this you will have "cracklings" left which are also good eating. If you have melted suet left, it may be used for cooking. This fat does not have any chemicals or preservatives in it and it keeps indefinitely. Do not have the fire hot enough for the grease to smoke. Strain it to get the cracklings out.

When both of these were done, I allowed the fat to cool a little in order not to cook the jerky when it was added to it and destroy the vitamin C in it. I then weighed out equal parts of the fat and powdered jerky and mixed them together well. If you wish, instead of weighing it you may simply add enough fat to the powdered jerky to moisten it. I then pressed this mixture into square loaf pans and allowed it to solidify. It was then ready to be sliced and eaten.

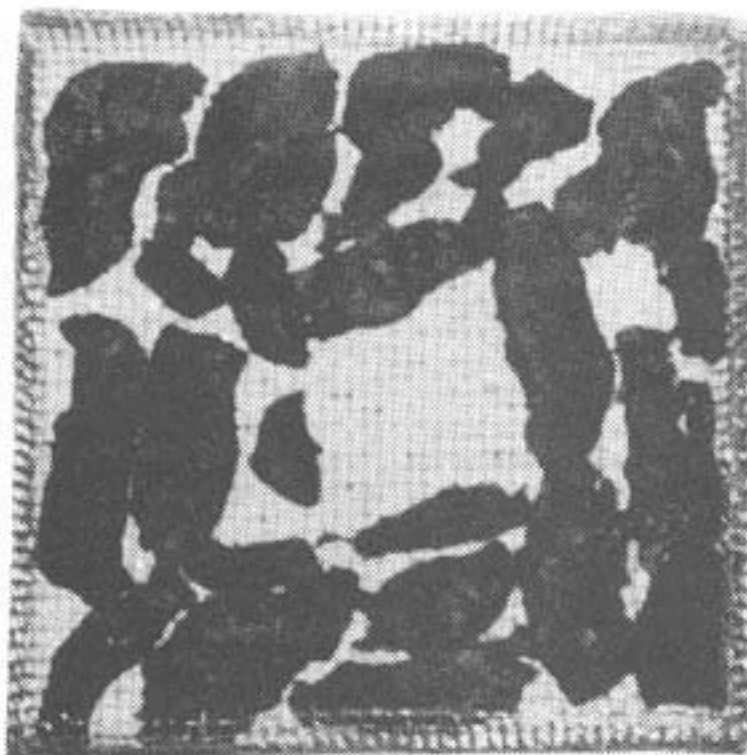
Do not dip the raw meat into boiling water or smoke it. This destroys the vitamin content and takes out the essential juices. Any heat hotter than the sun destroys the vitamin C to such an extent one will have scurvy from eating only pemmican of this kind over a long period of time.

Because of our food preferences and prejudices about food many people dislike pemmican at first but this can be overcome if we continue to eat it until we acquire a taste for it.

On a back-packing trek the joy of being able to cover more ground with a light pack and no time spent with food preparation and pots and pans should outweigh the dislike of a different food and a lack of variety in the diet.

I have not overcome my taste for salt so I add some to my pemmican. However, if I were going on a trip, I would not put salt in it because of the thirst problem. I also add some dried herbs to the fat before I mix in the jerky; dried minced garlic, dried minced onion, sage, oregano or whatever is desired. As I use herbs to keep my body in good condition, I can't see that they can do any harm in pemmican. In fact they would be a health benefit and to me, they improve the flavor.

McGill says pemmican can be made from dried fish. The fat is evenly distributed in fish already and it does not solidify when it is carried on a trip in freezing weather. It may be eaten just as



Before Drying



After Drying

retain the vitamins and preserve the natural color.

In THE SURVIVOR Vol. 3 is a complete course in home dehydration. It has all the details for fruit and vegetables, meat and fish. This article is just to get your interest. Once you make your own unit and make some jerky you'll be ready for more detail. SURVIVOR Vol. 4 will have the complete text of "Drying and Dehydration of Foods" from 1943. This is a commercial course for those who want to get into the business. And as food gets scarcer, drying it when it's in season and cheaper will insure the survival of a lot of smart people.

But to start, I urge you to make and test my simple unit. It takes no skill and less than \$10.

it is when it is taken off the drying rack. One does not need to know how to slice it for drying and it needs sunny weather and a good breeze.

I hope you will try pemmican. I think you will like it. Also, stock up a good supply of it for a crisis. Good health and good eating.

HERBS—A MUST FOR THE SURVIVALIST

by Jewell Watson

Those of us who have gone back to the land have learned the value of herbs. We also learned we had to be cautious and sure of those we used, the part of the plant to be used, harvesting and drying them, the preparation for their use and the amount to be taken.

Comfrey is one of the most important herbs we have and about as toxic as spinach. The leaves are good for poultices for bruises and swelling, broken bones, (one of its common names is knitbone) and can be used to stop bleeding. Tea made from them is good for kidney and bladder disorders. The roots contain allantoin which today's medical literature knows the value of for ulcerations both internal and external. A tea made from the leaves is good for colds and the leaves can be cooked and eaten as greens. Many of the herb teas do not taste good by themselves so we mix some of those which have a pleasing flavor with them or add a little lemon juice and honey. Comfrey is one of these.

One can make chicken soup from bouillon cubes, add a very small amount of sage, some dried parsley, dried celery leaves (dry them from a stalk bought from the super-market) minced dried onion and garlic and a very small pinch of thyme and rosemary. Some of these are very strong so use only a very small amount of those like sage, rosemary and thyme. Make it to suit your taste. All these herbs act like antibiotics in treating a cold and the soup also tastes good.

Chamomile tea is a very good but gentle disinfectant for the eyes or taken for internal disorders. When dropped in the eyes it must be allowed to cool a little and strained through cotton. It has so many small particles in it, it must be strained well if it is used in the eyes. It is also good for sluggish digestion, flatulence and insomnia. We also use it to water our young seedling plants to prevent damp-off.

For fever, neuralgia, influenzal aches and pains, premenstrual migraines and painful menstruation take a concentrated infusion of 1 tablespoonful of chamomile to

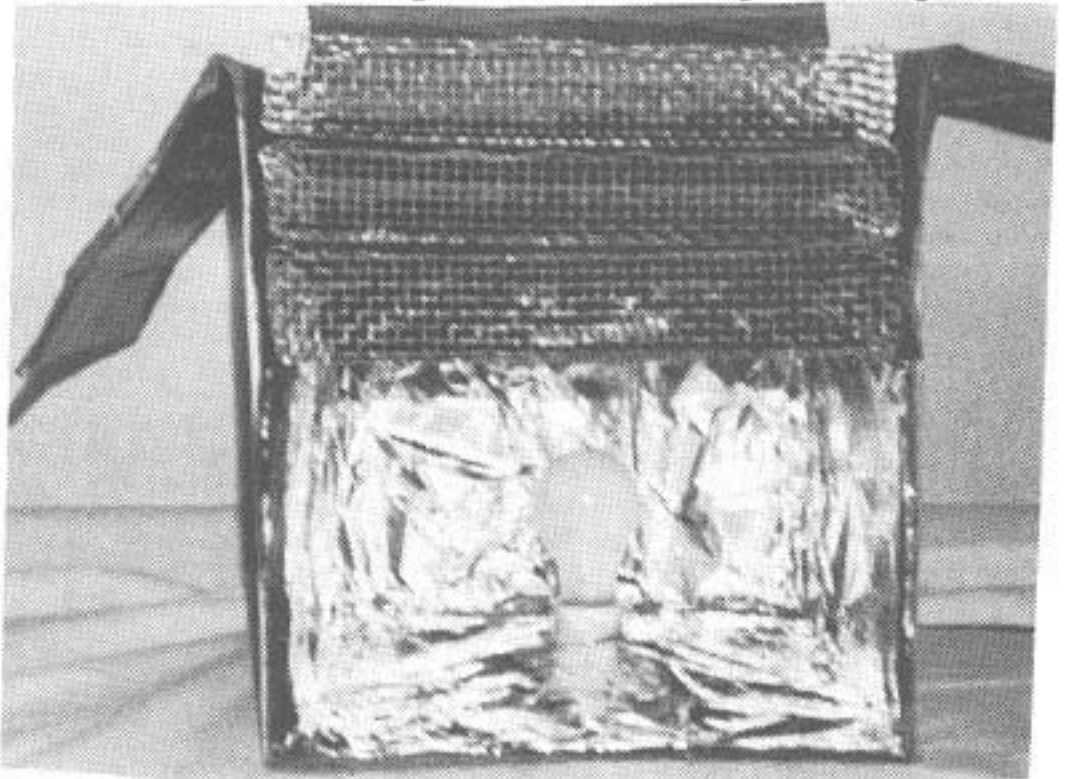
in materials. You can build in an afternoon and use it from now on. Since it has no moving parts it should never wear out.

For my unit I was fortunate in having the box my ice cream maker came in. It is one foot to a side and across and 21 inches from the bottom to the top of the flaps. To this simple box I added a common porcelain lampholder with lamp cord and plug, plus some aluminum foil. Aside from some duct tape and glue, that's all there is to it.

I asked the man who sold me the Ronco how much energy it used and he told me it used less than a 100 watt bulb. I put a 100 watt bulb in my unit. A 100 watt bulb uses 2.4 Killowatt Hours or 10 cents in 24 hours.

For trays I bought a square yard of 1/4 inch mesh galvanized screen for \$3.96 from the hardware store. From it I cut four 12 x 12 inch squares. At the corners I cut four 1 x 1 inch squares. Then I bent the sides up one inch or four meshes. I then bent the sides two meshes inwards so the trays would sit nicely one atop the other.

This screen is galvanized and perfectly safe



Cutaway view of dryer.

for meat and most vegetables. But the acids from fruits and certain vegetables such as tomatoes, might corrode the zinc coating. This is no problem. Just get a can of clear lacquer spray and spray both sides of the bottoms. The trays will then be ready for anything you wish to dry and will also be washable.

I added a touch Ronco didn't have. I put a 12 x 12 inch square of aluminum foil on the bottom of the dryer, over the projecting mouth of the socket without the bulb. This is easily done. Simply lay the aluminum foil, shiny side up, over the socket. Mash to get the imprint and then use a razor knife to cut the aluminum around the neck of the socket. An added touch was a layer of plastic wrap on the

about 4 ounces of boiling water; leave to infuse for an hour; strain and press through a cloth. A few drops of lemon juice seems to reinforce its action.

A tea made of the leaves of the mullien plant is good for colds, bronchitis, coughs, hay-fever, asthma, sore throat, earache etc. — any kind of respiratory ailment. It works beautifully for earache although it sometimes takes a number of days using it twice a day. Its leaves are so fuzzy it must be tied in a cloth or put in a tea ball as the fuzz comes off in the mouth and throat. The taste of the tea is very much improved with a few drops of lemon juice. For earache the warm tea may be dropped in the ear.

We keep an aloe vera plant in a pot in the kitchen for burns; pinch a piece of it off, break it open and apply the juice to the burn. Although one may buy the liquid from the plant at drug stores to be taken for stomach and other disorders, be careful that you do not try eating the plant as the outside covering is a violent purgative.

We plant seeds of oranges, lemon and grapefruit in containers so we can bring them in during the winter. We use the leaves of these fresh in our herb teas. They are delicious and good for you. The orange flowers may also be used if you can get them to bloom. The seeds must not be allowed to dry out if they are to germinate, place them directly from the fruit into the soil.

Dr. Cazin wrote long ago that orange-flower water is in frequent use for spasms, convulsions, palpitations, nervous colic and hysteria. The flowers and leaves picked directly from the orange tree still have the same sedative effect upon the sympathetic nervous system and are a remedy for insomnia. Take three or four cupfuls of the tea each day—one to be taken at bedtime. To make the tea take three or four leaves to a cupful of boiling water and steep for ten minutes. The orange is very high in vitamin C and a preventative for scurvy but rose-hip tea contains many times more vitamin C than oranges.

For liver complaints select lemons that have not been sprayed with preservatives, or wash them well, pour about a quart of boiling water sweetened with a tablespoonful of honey, over a lemon cut into rings and unpeeled. Let it infuse and drink warm in small cupfuls during the day. For influenza and colds, go to bed and drink the juice of a lemon in a cup of hot water sweetened with honey. For sore throats or irritations in the mouth use the above in a glass of water as a gargle.

Sachets of dried lemon peel hung in closets or cabinets will prevent moths and lemon peel scattered in an area where the kitty is not supposed to go will keep her away.

The lemon is antiscorbutic as well as an

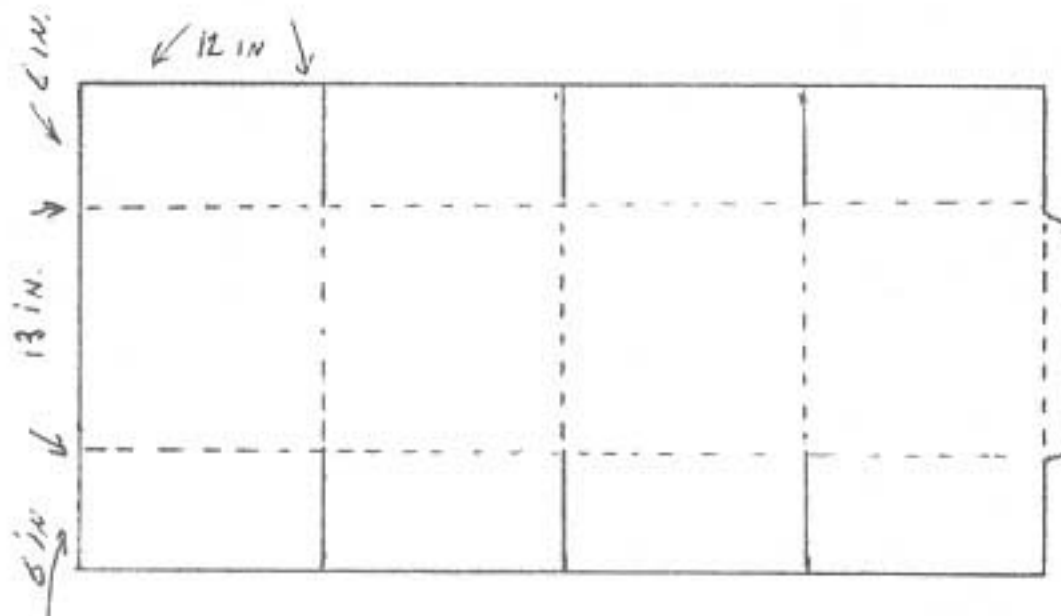
bottom. This is to catch the drips so there will be no cleanup job after each drying.

The lightbulb should be two inches beneath the bottom tray. To keep the trays above the light I cut a 7 x 46 inch strip of corrugated material from another box. I bent it every 11 1/2 inches. I then folded a strip of aluminum foil, shiny side out, around the strip. I then bent it into a square and put it in the bottom of the dryer.

Now the dryer has plenty of heat reflecting area and the strip is thick enough for the bottom tray to rest on.

MATERIALS LIST

Several square feet of corrugated box.
Five feet of aluminum foil.
Duct tape.
Glue.
One square yard of 1/4 inch mesh galvanized screen.
Medium base porcelain lamp holder.
Six feet of lamp cord and plug.
One 100 watt bulb.



The diagram shows how to lay out the box. The broken lines are to be bent and the other lines are to be cut. After folding the box, the tab at the right is bent and covered with glue and the left side is pressed over it to hold it just like any box is glued. The bottom flaps are bent in and glued and the box is complete. The top flaps are bent over and weighted shut while the dryer is on.

OOPS!

A few more notes on jerky:

My second and largest batch went into a zip-lock bag of the largest size. The meat was so dry I didn't even bother to zip it after taking out a portion but just folded it over and put it away. As I continued to eat it I gradually noticed a taste like meat which is starting to turn. Properly dried meat, whatever spoiled it, would not have that taste. So I realized I had not properly dried it. This was mainly meat cut

antiseptic and a bactericide. It is a well known fact that lemon juice can kill bacteria in a quarter of an hour.

I planted the seed of a papaya in a container and use the leaves as a tenderizer when cooking meat.

We use mint for digestive purposes, upset stomach and flavoring for food and drinks. We dry some and keep a pot of it growing in the kitchen.

We also bring in a pot of basil for the winter. It is good in many dishes as well as an excellent tea for nervousness and stomach disorders. It is a sort of natural, non-toxic "tranquilizer" and has a delightful fragrance. Hang a small bag of it in closets and place it among the linens. Planted among our tomatoes it repels insects.

The yarrow plant provides us with an ointment which is good for cuts and abrasions, burns and skin infections. We heat Crisco very hot but not smoking, take it off the fire and drop the cut-up plant roots and all, into it and let it set until it is cool enough to handle then squeeze it through a cloth into a jar. Yarrow also repels Japanese beetles, ants and flies. It is high in potassium and is used to treat symptoms of flu and common cold. It is said that yarrow is better than quinine for fevers.

The leaf powder from the yucca plant is used for skin infections. I dry the leaves, powder them in my Vita-Mix machine, heat Crisco, mix the yucca powder well into it and let it cool to make the ointment. The roots when swished around in water make a sudsy wash for externally caused skin disorders, eruptions and slow-healing ulcers. One of its common names is soapweed.

A decoction of the flowers of the violet is prescribed for colds, bronchitis, coughs, whooping cough, irritations of the respiratory tract and headaches. To make it take 3 or 4 teaspoonfuls of dried flowers to a quart of water, cold soak for a few minutes, bring to a boil and leave to infuse ten minutes. Drink 3 or 4 cupfuls a day between meals. A decoction of the root is an emetic.

In gathering and drying herbs, gather them in the morning after the dew has dried on them. Wash them and hang them up in the shade to drip dry. I then take them down, place them in brown grocery sacks, label them and pin them with clothes pins on a wire I have across one end of my kitchen. It may take a little longer to dry them in sacks but it is less trouble and cleaner.

Some of the herbs, of which only their

thicker than that which had indeed dried. Also, I noticed that mold was beginning to form on some of the pieces. I put it all back in my dryer and left it for several hours. (You can't over-dry jerky). I then remembered I had noticed water droplets on the sides of the upper part of the dryer. I should have left the flap open about a half inch to let the water vapor escape. It was partly the inability of some of the water to escape and partly because some of the beef was cut thicker than that I had judged to be dry.

Afternotes: Dry twice the time to make sure. At 10 cents per 24 hours you can afford to dry jerky longer to make up for pieces which are thicker. Leave a slight opening at the top for the water vapor to escape through. When finished, put all jerky not for immediate use in jars and lay the jars, lidless on their sides on the first tray and dry for an hour more. Put the lids in the dryer, too. After that hour, without removing the jars or lids, screw on the lids and then the finally dried jerky should keep indefinitely.

SAVING \$ WITH A THERMOS BOTTLE

Many subscribers write that they will eventually buy all my books but they can't afford them at this time. Many are students on limited allowances. Some are on Social Security or pensions. Others are on Welfare, as I was after an injury, when I got \$86.00 per month in 1969. I paid \$50.00 for rent and had only \$36.00 left for food and incidentals. Even so, I ate better than before. Prices were indeed lower then but, surprisingly, the costs of the more basic foods have hardly changed.

For instance, 50 lbs of hard red winter wheat, the highest in protein, minerals and vitamins, averages \$14.00. (200 breakfasts at 7 1/2 cents). Brown rice, also higher in nutrition than white, costs \$14.00 for 25 lbs. (Also 200 hundred servings since rice swells twice as large as wheat). These are bought in bulk at any health food store.

Wheat and rice are the staple foods of billions and if prepared my way will fill you up, give you boundless energy; and cost nothing, if you consider that the saving in gas or electricity will offset their purchase prices.

I don't mean that wheat and rice, plain, is what I'm asking you to live on. When is the last time you've eaten a potato plain? I'm simply suggesting you process all your food in inexpensive, energy-saving ways and eat better than you ever have for less than \$10.00 per week. Then you can

Continued on page 1098

HEALTH BEER

by Susan Kramer

Why do I say "health beer?" One reason is the blackstrap molasses. According to the NUTRITION ALMANAC blackstrap molasses contains calcium, iron, magnesium, phosphorous, sodium, B1, B2, B6, B12, niacin, inositol, and even a little folic acid. Some of these nutrients are used by the yeast critters, however some go right down the hatch with your beer. Also contributing to the "healthfulness" of this beer is the use of dextrose rather than sugar. Dextrose is a very simple sugar that is easily and thoroughly digested by the yeast. White sugar must be broken down by the yeast and leaves a residue that is not used by the yeast. Those who drink the dextrose beer rather than the white sugar beer say that there is less of a hangover when indulging in the dextrose brew. Malt extract also has food value.

Those who get all they need nutritionally never become alcoholic. When nutritional needs are satisfied people need not drink in an uncontrollable manner any longer. (Read Rodale's HEALTH FINDER page 32.)

EQUIPMENT:

1. Pan to heat water
2. Five gallon plastic bucket
3. Siphon hose
4. A dozen quart canning jars
5. Two pounds of dextrose (corn sugar), or plain white sugar
6. Beer yeast
7. Unsulfured blackstrap molasses (two quarts)
8. Malt extract (use amount specified on the can you buy)

Boil ten quarts of water and cool until you can hold your finger in for at least ten seconds. Pour into plastic bucket and add dextrose, molasses and malt. Dissolve yeast in about one half cup of the mixture and let stand until you can see it working (three to five minutes). Add the yeast mixture to the bucket. Cover and let stand in a warm constant temperature. After three days begin tasting the beer. When the sweetness is almost gone, siphon the beer into canning jars carefully, keeping the yeast sediment at the bottom. Part of this yeast can be used to start your next batch of homebrew. The rest can be used for baking breads, doughnuts, cakes, pizza, etc. See SURVIVOR 1, page 79, formula #1815, "To Preserve Yeast." Also, any excess yeast can be used as a nutritional supplement in any food dish by first boiling it to kill the yeast's action.

Yeast is an organic body that thrives in a sugary solution and gives off carbon

not only afford all my books but many other things you've wanted but had to do without because most of your food budget goes to pay others to do what you should learn to do for yourself.

In this issue I'll tell of the thermos and the dehydrator as first steps in eating better for so much less. I will get to steaming, the crock pot and the pressure cooker in subsequent issues. As a Survivalist, you will have to understand food preparation or you might as well eat, drink and be merry in the short time you have left.

A great factor which makes this course practical and easy to understand is that since it's by a man, it is basic, gut-level and moron-simple. You won't even need to open a cookbook.

First the thermos. There are three kinds but only one is practical. Forget the cheap, plastic ones lined with styrofoam. These might cook oatmeal and white rice but do not have the heat holding power you need. Silvered glass thermoses are fine, but a bump will break them. Also, since you are going to do actual cooking and will use a fork to remove the contents, they won't hold up.

The only practical cooking thermos is the Alladin Stanley. It is lined with stainless steel, is well insulated and will keep steaming hot for up to 24 hours and holds a quart. It is also unbreakable, with a lifetime warranty. It costs \$19.00 at Wal-Mart or can be ordered through any sporting goods store. It would save you its price in a few days. If you have a family, get two or three.

Most foods cook at 180 degrees or more. We are used to boiling, which is 212 degrees, and foods do cook faster, the higher the temperature. But if time is not important, cooking at a lower temperature is even better as most vitamins are not broken down. Thus, if you cook at a minimum heat you save nutrition.

A great factor in thermos cooking is the saving in the cost of energy. Whereas it would take about two hours to cook whole-grain wheat or nearly an hour to cook brown rice, thermos cookery takes only five minutes to cook anything. So it is indeed possible to save as much in energy as you spend on the food. You can imagine the convenience of thermos cookery in camping, which would save on wood, weight of food carried, and no food odors to alert bears or enemies.

Thermos cookery is also an advantage to anyone living where he is not allowed to cook. There are no cooking odors to tip off the landlord.

First, you need the thermos. Then you need a heat source. If you are in a non-cooking room, buy a cheap, one burner hotplate from your local Wal-Mart, Target, Sears, etc. You'll need a one-quart saucepan. You'll also need a special funnel to quickly pour the pan's contents into the thermos, plus a spoon or fork to help the last of the food into the funnel.

To make the funnel, cut off the bottom four inches from a gallon plastic milk container. If you

dioxide and alcohol (the drinkable type) as waste products. Unfortunately for those of us who like a strong alcoholic drink, it is impossible to make beer containing more than twenty percent alcohol. An alcoholic solution of above twenty percent renders the yeast critter dormant. So even adding more dextrose or yeast will not make your beer more potent than 20% alcohol.

Beer yeast can be found in hobby shops, head shops, specialty stores, or large department stores that carry homebrewing supplies. I bought mine at Pacific Paraphernalia, 1087 H Street, Arcata, California 95521. You may also want to check your local library for books on beer making that may contain listings of outlets for beer making supplies.

Store the "Canned" beer in a cool place and age it. When you are ready to drink it, carefully pour into another container (larger than a quart so that the head will not run over) leaving the yeast sediment in the canning jar. This yeast can also be used to bake bread or as a nutritional supplement. If a jar breaks due to too much pressure, simply loosen the lids and let out some of the "Fiz." This is an advantage of using canning jars rather than capped bottles.

THINGS TO CONSIDER

If any of your equipment used is not sterile you may introduce another yeast into the batch. This may give a foul taste. Keep it clean.

If you use sulfured blackstrap molasses instead of unsulfured the sulfur will kill the yeast.

If you question the purity of your water (most city water is full of chemicals) then buy distilled water or find a fresh mountain stream. My water comes from a spring but I still boil it to be sure there is not another yeast besides the one that I introduce.

This is an easy way to brew your own beer. You can make your own malt extract, by sprouting, roasting, gristing, and steeping grain. Make your beer stronger or weaker. Experiment with the flavor by adding wormwood or other herbs. A strong tea of sassafras and sarsaparilla can be added for a root beer taste. This is just a way to begin your study of the "art of homebrew." Cheers! ☐

SALT HORSE

by Boyd Hill

An often overlooked method of preserving meat is the old brine pickle that created the "Salt Horse" of the days of sailing ships. Meat—particularly beef—thus embalmed would keep for many years, even in situations of extreme heat and humidity.

Today's corned beef resembles sailing

Aladdin does make wide-mouthed thermos bottles. They would be more convenient. But the wide mouth has much more surface area and so doesn't retain the heat as well for cooking.

Aladdin

STANLEY

Built to Last a Lifetime!

The Stanley bottle was designed with you in mind ... it will meet any challenge and continue to perform.

Insulated Cup
Chrome-plated cup has foam insulation to keep your drinks hot or cold longer.

PourThru™ Stopper
Convenient Pour-Thru stopper will not leak. Lets you control the flow.

Unbreakable Steel
Rugged outer is made of heavy-gauge steel. Stainless steel inner has no glass to break.

Insulated Wall
Vacuum insulation and charcoal barrier will keep your drinks hot or cold longer.

Carry and Pour Handle
Convenient handle is contoured for comfort and folds flat for storage.

Chrome Base
Durable steel base will not crack; chrome-plating retards rust.

ship beef about as much as a raccoon is like its distant cousin, the Grizzly Bear. When dried it could be cut and polished like a rare-grained exotic wood. They even made snuff boxes of the stuff.

It would be hard to find an oak "harness cask" today, and it isn't necessary. From your friendly neighborhood fast food emporium get several of those two-gallon-plus plastic bulk mayonnaise jars.

Get the beef on the lean side (any tough cut will do fine) in two to four pound chunks. Trim off as much fat as possible. Stuff the meat into the mayo jar until the container is almost filled.

Then make up your pickle brine, dissolving enough salt in the water until a peeled potato will float in the solution. For each gallon, add a quarter ounce (about a half teaspoonfull) of saltpeter which, among other things, helps keep the beef a healthy red color.

Fill the jugs to the top with the brine, and shake the jug to make sure each piece of beef is completely surrounded. Then force ALL the beef well under the surface, and wedge it down with pieces of clean wood. This is very important. If the smallest amount of meat appears above the solution it will go bad, and ruin all the rest of the beef in the jar.

After a week test the strength of the solution with a piece of peeled potato. If it doesn't float, add more extra salty brine until it does. Keep up this inspection system for the traditional one month and one day. Make it 33 days and you'll be extra safe: your Salt Horse will keep for years, and possibly decades. Then top off the jar with more brine and screw the lid down very tight.

Sea cooks used to tow this meat behind the ship for twenty four hours to soak out the brine. For those not afloat (Salt Horse was also an old time Army ration) it could be readied by soaking in lots of fresh water for 12 hours, and then pouring off the water and re-soaking for another half day.

MARIGOLDS. — Their virtues have been lost sight of. The juice, or a strong decoction, with (or without) a very small portion of spirits of wine, is a rare application for healing lacerations, bruises, cuts, both pain and bleeding being immediately arrested. By its use in severe wounds Erysipelas is prevented. It seldom leaves a cicatrix, or mark, behind it. It has a tendency to contract the mouths of the small arteries, when directly cut across, and where they have been slit longitudinally. The tincture may be purchased of the Homœopathic Chemists, and largely diluted with water, it is a first-rate remedy.

don't buy milk and can't find an empty container, go to your nearest laundromat. You will find, in the trash receptacle, an empty gallon bleach bottle. Use that the same as the milk container but wash it until there is no more bleach odor.

The first step in thermos cookery is to fill the thermos with water up to the point reached by the stopper. Empty the water into the saucepan and make a scratch or other indelible mark at the water's surface inside the saucepan. This will allow you to put just enough water in the saucepan, as too much will leave food out and too little will give you less cooking water.

Just to test how the cooker works, start with four ounces of wheat. You don't need to buy 50 lb. You can buy two lb from your health food store for about 80 cents. This would give you eight meals at 10 cents each.

In the evening, put four ounces in your saucepan, plus a half-teaspoon of salt to prevent flatness, even if you intend to sweeten it. Fill to the mark with water. (If you have hot water, let the tap run until it is hottest. Tests have shown that less energy is used in using hot tap water than in boiling from cold). Bring the contents to a rolling boil, stirring all the while. This will take from three to five minutes.

Then, quickly, but carefully swirl and pour the contents into the funnel and help any lagging matter from the pan to the funnel and into the thermos. Cap firmly but not tightly, shake and lay the thermos on its side, to keep the contents even.

Next morning open the thermos and pour its contents into the saucepan. With four ounces of dry wheat you'll now have at least 3/4 lb. of cooked wheat and about a pint of vitamin and mineral enriched water. It has a pleasant taste. Drink it.

You can now put milk and sweetener on it or margarine, salt and pepper, etc. If you can eat the whole 3/4 of a pound you'll be surprised at how energetic you feel for the next several hours. An added bonus is its high fiber content.

Having tried the four ounce portion you might next use eight ounces. This will absorb most of the water. It's unlikely that you could eat a pound and a half of cooked whole-grain wheat. You can either divide it and eat the other half for supper or if you're a family man, make it the family breakfast food to replace the expensive brand.

If you have children, get them into the act by fantasizing they are Rangers on a jungle patrol.

For lunch, prepare a few ounces of hamburger or other meat chopped finely, plus chopped potatoes and other vegetables the night before. After breakfast put these and the right amount of water in the saucepan and prepare as usual. At lunchtime you'll have a quart of really delicious stew. Since nothing leaves the thermos in cooking, as contrasted to the flavor leaving stew cooking on the stove, you can understand the better tasting, higher vitamin content of thermos stew.



Table Salt Prevents Burning of Jam

WHEN cooking marmalades, jams, or heavy liquids which require a slow fire for several hours, the danger of scorching may be prevented by the simple expedient of setting the kettle in a tin pan of table salt, as illustrated in the accompanying drawing. This salt serves as a cushion to diffuse the heat and prevent direct contact with the pan. The salt can be used over and over again. (One precaution, however: do not use an aluminum pie pan for the job, because it will burn through in a short time.—Hi Sibley.)

SNAILS ARE EDIBLE

The common garden snail, a pest, is good food. They were brought over here to raise for food and got loose and spread. After a rain they are all over the place and pounds can be picked up around any kind of garden. You can attract oodles of snails by pressing a shallow pan into the soil and filling it with beer. Then place a large piece of cardboard over the pan, held a couple of inches over it by two two by fours to provide shade. In the morning you collect the drunken snails.

Put the snails in a plastic lined box with a cover and feed them cornmeal. You can also feed them the leaves you find them eating but cornmeal is more convenient.

Unless insecticides have been used they

SNAILS NOW GROWN ON GERMAN FARM Popular Science 1934

are probably safe to eat right away. To be sure, let them eat cornmeal for at least 24 hours.

I'm not sure of the procedure for raising the offspring to edible size but if you really want to go into it commercially I'm sure your library will have books describing the garden snail's life cycle.

Before preparing them for eating, let them go another 24 hours without food so their systems will be cleaned out. Then drop them into boiling water for about five minutes. Then spread the openings with garlic butter. You can easily pick out the snails with a small fork or toothpick.

In a restaurant they are called escargot and are a delicacy.



A SNAIL farm not far from Berlin, Germany, lays claim to being the only place outside France where these land-going mollusks are raised for food. Bushels of the shell-covered creatures are shipped from this establishment to German and French markets, where they are considered a table delicacy. Because their wanderings cover an area surprisingly large, the snails on the German farm are confined by miniature wire fences like the one seen enclosing the field in the photograph at left.

Lunch and possibly supper shouldn't cost you more than 25 cents if you study the article on the dehydrator. Jerky and dried vegetable stew is good and costs little.

The brown rice dishes could also be either main course or desert. Brown rice has a much greater swelling factor than wheat so four ounces of rice will pretty much fill the thermos. You can put vegetables and meat in it to cook or try a favorite of mine. It is four oz. brown rice, 9 cents; one oz. powdered milk, 10 cents in large box; two oz. raisins, 22 cents; one teaspoon of salt, some cinnamon and four saccharine tablets. Cook overnight. This is 46 cents for 1 1/2 lb. of desert.

With some experimenting you can become an expert in thermos cookery. If you are single and live alone you could, conceivably, eat nothing except what you cooked in a thermos. But if you are married, and especially if you have children, don't push it. Even with the economy of this system, it's not worth alienating your family. If your wife doesn't like it, challenge her to make the food tastier and think up some thermos recipes. You might also tell her the advantages of thermos cookery.

For one thing, she'd spend much less time in the kitchen. What with the expected brownouts she could do all the cooking in five, ten, fifteen minutes, depending on how many thermos bottles she used. Another important factor is that, especially during the heat waves, the home wouldn't suffer the added heat from the kitchen. This would also cut down on the air conditioning costs.

A tip you may not have known is that the pilot light in a gas stove not only raises the temperature in the kitchen but also accounts for a fourth of all the gas burned in the stove. Matches are much cheaper. Turn the pilot light off.

Be sure to get SURVIVOR Vol. 1 for a full course on inexpensive but tasty and nourishing food, plus sprouting for green vegetables, soy milk, tofu, etc.

DRYING - ONE OF THE OLDEST METHODS TO PRESERVE FOOD

COOPERATIVE EXTENSION SERVICE

University of Arkansas Division of Agriculture and U. S. Department of Agriculture, Cooperating

For thousands of years, people have dried many foods to preserve them for leaner times. Preserving seasonal foods by drying is still useful and convenient, and it has the added advantage of conserving storage space.

How does drying preserve food? Basically, sufficient moisture is removed from a food material to prevent its decay; water content of properly dried food can vary from 5 percent to 25 percent.

In hot, dry climates, food will be reduced in a few days to a moisture level that preserves them. In any climate, however, you can create satisfactory drying conditions at a moderate expense by using artificial heat and circulating air over the food.

This publication tells how to prepare vegetables and how to prepare and pre-treat fruits for drying. Then, it tells you how to dry them—

- in your own kitchen oven (you need drying trays, an oven thermometer, and a small fan)
- in a portable vegetable dehydrator (see appendix for instructions on how to construct a natural-draft vegetable dehydrator, or see Oregon State University circular 855, also included here, for instructions on how to construct an electric food dehydrator)
- in the sun (you need the drying trays, temperatures over 98° F, and low relative humidity)

Finally, recipes are included for dried food specialties—fruit leathers, beef jerky, salmon jerky.

VEGETABLES

PRE-DRYING TREATMENT

Select your vegetables carefully. If they are not fresh and are not in prime condition for cooking, they are not suitable for drying. Vegetables not listed in table 1 can be safely dried, but quality will be sacrificed. Vegetables should be washed and prepared on the same day they are harvested. (See table 1.)

Blanching

Blanching is the process of heating vegetables sufficiently to inactivate enzymes. Enzymes are the biological catalysts that facilitate chemical reactions in living tissue. If certain enzymes are not inactivated, they will cause color and flavor to deteriorate during drying and storage. Blanched vegetables, when dried, will have better flavor and color than unblanched ones. You may blanch with hot water or with steam. Water blanching usually results in more leaching of vegetable solids, but it takes less time than steam blanching under kitchen conditions.

With steam. You need a kettle with a tight fitting lid to use as a steaming container, a colander, wire basket, or sieve that will fit in the kettle. Add 1½ to 2 inches of water to the steamer, and heat to boiling. Place the colander, basket, or sieve containing loosely packed vegetables into the steamer and leave until the vegetables are heated through and wilted. See table 1 for recommended blanching times. Test by cutting through a piece of food. If sufficiently blanched, it should appear cooked (translucent) nearly to the center.

With water. Use only enough water to cover the product. Bring the water to a boil and

gradually stir in the vegetable, following the directions in table 1. Re-use the same water for additional lots when blanching the same vegetable, adding new water as necessary. Keep the lid on the kettle while blanching.

DRY THE VEGETABLES

Drying in the kitchen oven or in a dehydrator is recommended; however, sun drying may be used under proper conditions.

In the oven

1. Trays must be at least 1½ inches narrower than the inside of the oven to allow for air circulation. Allow at least 2½ inches between trays and 3 inches of free space at the top of the oven. Cheesecloth may be spread over the trays (under the food) to prevent small pieces from falling between the slats.
2. Load two to four trays with no more than 4 to 6 pounds of prepared vegetables distributed among them. Vegetable pieces should be in a single layer. More than one kind of vegetable can be dried at the same time. Strong-smelling vegetables should be dried separately.
3. Place an accurate and easily read thermometer on the top tray toward the back.
4. Preheat the oven to 160° F (71° C), and then add the loaded trays. Prop the door open at least 4 inches.
5. Place a fan outside the oven in such a position that air is directed through the opening and across the oven. Change the

position of the fan frequently during drying to vary the circulation of air.

6. Maintain the temperature at 140° F (60° C). It takes less heat to keep the temperature at 140° F as drying progresses, so watch the temperature carefully toward the end of the drying.
7. Examine the vegetables often, and turn the trays frequently. At the start of the drying process there is little danger of scorching, but when nearly dry, the product may scorch easily. Even slight scorching destroys the flavor and may lower the nutritive value, so be careful not to allow the temperature to rise above 140° F, especially during the latter stage of drying.
8. Consult table for correct drying periods.

NOTE: Tests for dryness will come with experience. The approximate drying times are merely a guide to judging proper dryness. Vegetables should contain from 2 to 6 percent moisture after drying.

In a vegetable dehydrator

Dehydrators are made from scrap lumber and other readily available materials (see appendices).

1. The natural-draft dehydrator will hold 7 to 9 pounds of prepared leafy vegetables or about 14 pounds of non-leafy vegetables. The electric food dehydrator will accommodate approximately 18 pounds of fresh, moist product. Distribute the vegetables on the trays in a single layer. Cheesecloth may be spread over the slats for drying small pieces. Different kinds of vegetables may be dried at the same time. Strong-smelling vegetables should be dried separately.
2. Preheat dehydrator to 160° F.
3. In the natural-draft dehydrator, place the trays of prepared vegetables with the top tray nearly touching the door and the second tray nearly touching the rear wall. Alternate the other trays in a similar way. This arrangement forms the channel which forces the air evenly over all the trays. From one to seven trays may be used. (The construction of the electric food dehydrator provides even air flow.)
4. Place an accurate, easily read thermometer on the bottom tray.
5. After the trays are placed in the dehydrator, the temperature will drop. Bring the temperature up to 140° F to complete the drying.
6. Examine the vegetables from time to time (1½- to 2-hour intervals, depending on the vegetable). To get uniform drying in the natural draft dehydrator, rotate the trays; if necessary, turn the product.
7. At the start of the drying process there is little danger of scorching, but when

nearly dry, the vegetables scorch easily. Even slight scorching destroys the flavor and may lower the nutritive value, so be careful not to allow the temperature to rise above 140° F, especially during the latter stage of drying.

8. Be sure to place the natural-draft dehydrator in a well-ventilated room, so that the water vapor will be carried away.
9. The time for drying varies according to type of vegetable, size of pieces, and load on the tray. The time at 140° F usually ranges from 6 to 16 hours (see table 1).
10. Be sure to cool the material before testing for dryness.
11. After food has finished drying, and dehydrator has cooled, trays may be cleaned with hot, soapy water, then rinsed, and dried.

In the sun

Drying in the sun is unpredictable unless temperatures are over 100° F, and the relative humidity is low. If the temperature is too low, humidity too high, or both, spoilage (souring or molding) will occur before drying is achieved.

Place the prepared vegetables on clean trays, as for dehydrator drying, and cover the trays with cheesecloth to guard against insects. The trays should not be stacked for sun drying. The cheesecloth should be raised above the trays so that it does not contact the product, but be sure to protect the sides against insects. Such a cover will slow the drying process.

Turn the vegetables once a day to facilitate drying. If the temperature at night is more than 20° F lower than daytime temperature, place the trays under shelter. It will probably take 3 to 4 days to complete drying, depending upon particle size, air temperature, and type of product.

PACKAGING

Dehydrated vegetables are free from insect infestation when removed from the dehydrator or oven. However, they are immediately susceptible to contamination and should be packaged as soon as they are cool. Use dry, scalded, insect-proof containers such as home canning jars with well-fitting lids. Coffee cans may be used if the dried vegetables are first placed in a plastic bag. The vegetables should be packed into the container as tightly as possible without crushing.

Despite precautions, sun dried vegetables may be contaminated by insects. Therefore, the packaged dried vegetables should be placed in the home freezer for 48 hours to kill any possible insects or their eggs. Containers and storage areas should also be rodent-proof.

STORAGE

Containers of dried vegetables should be

stored in a dry, cool, and dark place. Low storage temperatures extend the shelf life of the dried product.

All dried vegetables deteriorate to some extent during storage, losing vitamins, flavor, color, and aroma. For this reason, they will not retain their appeal indefinitely.

Carrots, onions, and cabbages deteriorate at more rapid rates than do other vegetables, and will generally have a shelf life of only 6 months. Some vegetables, however, will be good after a year's storage.

NUTRITIONAL CHANGES IN VEGETABLES DURING DRYING

Fresh vegetables provide man with bulk, energy, minerals, and vitamins. Bulk is provided by the indigestible fiber, and energy is provided by the starch, sugar, and fat. Neither bulk nor energy is affected by the drying process.

During blanching, a portion of the minerals and vitamins is lost by leaching, the amount depending upon the care exercised in blanching. To keep leaching to a minimum, blanch only as long as required. Do not under-blanch, however, because the enzymes will not be inactivated, and the dried vegetables will be of inferior quality. Even though some nutrient losses during drying are unavoidable, a tasty, as well as a wholesome product can still be prepared if the proper directions for blanching, drying, and storage are followed, and the vegetables are consumed as early as possible to keep nutritional losses to a minimum.

COOKING DRIED VEGETABLES

Water removed during drying must be replaced either by soaking, cooking, or a combination of both. Root, stem, and seed vegetables should be soaked for ½ to 2 hours in sufficient cold water to keep them covered. After soaking, simmer until tender, allowing excess water to evaporate.

Greens, cabbage, and tomatoes do not need to be soaked. Simply add sufficient water to keep them covered, and simmer until tender.

Many vegetables lose their fresh flavor during drying. For this reason, flavorings such as basil, garlic, onions, and chili sauce may be added during cooking to improve flavor.

Dehydrated vegetables are usually not used as cooked side dishes. They are best when used as ingredients for soups, casseroles, sauces, stuffings, and stews. Various combinations of dried vegetables may be used, but caution should be exercised not to add too much dried onion or garlic.

FRUITS

Drying does not improve the quality of fruit. For this reason, use only fully ripened fruit. If it is not suitable for eating fresh, it is not suitable for drying.

PRE-DRYING TREATMENT

Sort and discard defective fruits. Wash, pit, and halve when necessary (as with stone fruits). Most fruit must be treated (immediately before drying) to maintain an appetizing appearance—and to prevent darkening, loss of flavor, and vitamin C.

Although we give instructions here for steam and water blanching, the sulfur treatment described first is preferred as a pre-drying treatment. Sulfuring fruit (exposing it to sulfur fumes) is not only easy, it effectively maintains the quality and the nutrients of food during drying and storage.

Some fruits to be dried whole may be dipped in a lye solution to make them dry faster. (See table 2.)

Sulfuring: materials you need

Trays, slatted, wooden. *Do not use aluminum or galvanized screening material,* as sulfur fumes corrode most metals. If wooden, slatted trays are not available, wooden lids from lug boxes may be used.

Thread spools, wooden or plastic (but not styrofoam) or small, wooden blocks. Place at corners of trays to stack them 1½ inches apart.

Box, heavy cardboard or wooden (no cracks or openings). Must be large enough to place over stacked trays with 1 to 1½ inches to spare between the trays and the inside of the box. Box should also be large enough to accommodate the container of burning sulfur under the stacked trays.

Fire bricks to raise the stack of trays high enough off the ground to accommodate the container of burning sulfur.

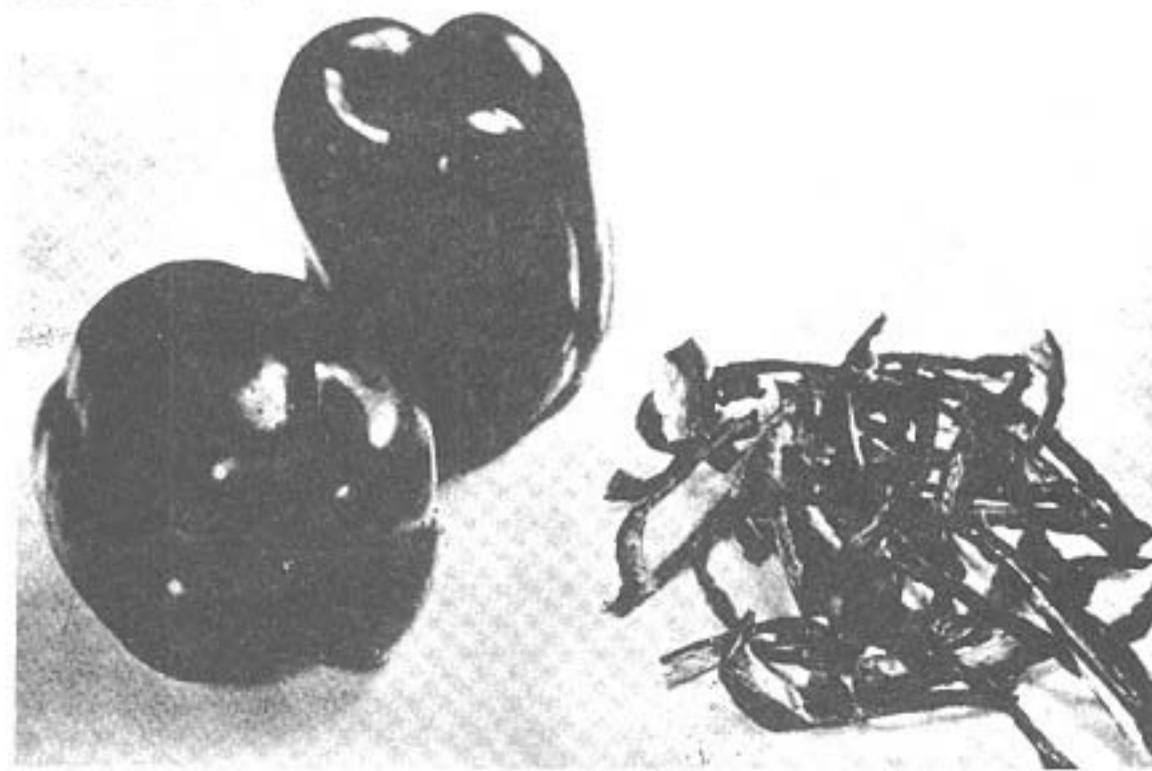
Sulfur. Use elemental sulfur also called Sulfur Flowers (U.S.P. standard) or flowers of sulfur. It is free of impurities, burns readily, and may be purchased at most pharmacies. Sulfur preparations for garden dusting may be used if they are 95 percent sulfur with only 5 percent impurities. However, these preparations are more difficult to ignite and may require the use of a torch to get them started. This sulfur may be purchased at a nursery, garden supply shop, or a feed supply store.

Clean, metal container to hold the sulfur. For small amounts of fruit, a 1-pound coffee can or an aluminum pie tin will be large enough.

And how you do it:

Always sulfur outdoors away from close contact with plants, shrubs, and trees. Consult table 2 for correct sulfuring periods for different fruits.

1. Spread fruits in a single layer, pit cavity side or cut surfaces up, on trays. Pieces should not touch each other.
2. Stack trays 1½ inches apart, separated



Fresh bell peppers (left) and dried strips of peppers (right). Pepper strips were not blanched, and were dried in a dehydrator.

by spools placed at the corners.

3. Cover the stacked trays with the box. Make a slash at the bottom of the box and another slash at the upper edge of the opposite side (as shown in the drawing). Open slashes when necessary to permit circulation of sulfur fumes.
4. Measure the sulfur and place it in the container. The amount used varies with the length of time the fruit is to be sulfured, weight of the fruit, and the dimensions of the box. Generally, if you are using a cardboard box to cover the trays, you will need to use 1 tablespoon of sulfur per pound of fruit (weight before drying). If you have constructed a more air-tight sulfuring box from wood, you only need to use 1½ teaspoons of sulfur per pound of fruit. (A stack of four trays holds about 40 pounds of fruit.) Sulfur fumes do the work, not the burning. Sulfuring is complete when fruit appears bright and glistening, and a small amount of juice appears in the pit cavity.

The burning time of sulfur will vary with the ventilation, shape of container, and weather conditions.

5. Place the can of sulfur under the box near the lower opening and light the sulfur. Because of the heat resulting from the burning sulfur, space is necessary between the sulfur and the sides of the box, and between the sulfur and the first tray. Do not leave burned matches in the container.
6. Immediately lower the box over the stack, and seal the bottom edges with dirt. Start timing.
7. When sulfur is burning well, close openings in box.

Blanching

Blanching as a pre-drying treatment gives a darker, less flavorful, and less nutritious product than does sulfuring. Blanching also produces a slightly cooked flavor, particularly with pears, cling peaches, and apricots. With either steam or water blanching, the skins may loosen enough to peel off, and the fruit is sometimes soft and difficult to handle. The skins on freestone peaches, for example, may be slipped off easily after blanching. (In commercial operations skins usually are not removed.) Peeled fruit may stick to the drying trays.

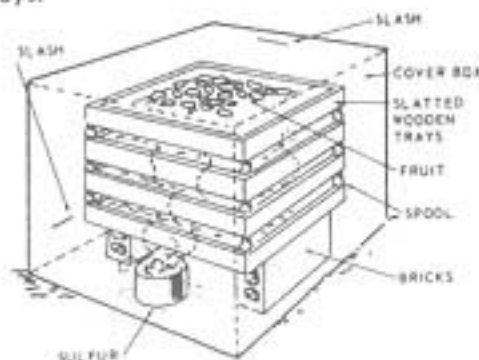


Diagram of a homemade sulfuring box using a large cardboard carton to contain the fumes of burning sulfur.

With steam. Blanch in a colander or strainer in a double-boiler type of arrangement. (See table 2 for preparation of fruit.)

With water. When water blanching, do not cut fruit. Place whole in enough boiling water to cover them (see table 2 for length of time). To each quart of water, add ¼ cup of lemon juice or 1 tablespoon lemon juice and 1 tablespoon ascorbic acid. (Five tablets of vitamin C—1 gram potency—may be substituted for the 1 tablespoon ascorbic acid. Crush before adding to water.)

Cut and pit fruit after blanching.

Dipping fruit in a lye solution

Some whole fruits (see table 2) may be dipped in a lye solution to make them dry

faster. Place 2 level tablespoons of lye in 1 gallon of cold water. Stir with a wooden spoon or clean stick. Bring to a boil. Dip the fruit in the boiling solution (being careful to avoid spattering) for 5 to 30 seconds, depending on the toughness of the skins and the size of the fruit. The dipping should be long enough to form many small cracks in the skin when the fruit is washed. *Rinse the fruit thoroughly in cold water to remove all traces of lye.*

To dispose of a lye solution

Pour it carefully down the sink drain. Rinse the sink and utensils with large amounts of cold water. Or, pour the lye solution carefully into the toilet bowl and flush several times.

CAUTION: Lye attacks most metals and can cause serious burns to the body. Use rubber gloves when handling. If lye contacts the skin, wash immediately with water.

Under no circumstances should the lye solution come into contact with any metal other than stainless steel. Lye in contact with any metal that is not stainless will form salts that will change the flavor and color of the fruit and introduce a health hazard. Enamelware may be used if it has no chips or cracks.

DRYING, PACKAGING, AND STORAGE

Drying fruits is not very different from drying vegetables. You may dry fruits in the oven, in the sun, or in a dehydrator you build yourself with the directions provided in this publication. These methods are described on pages 9 to 12 and 16 to 20.

However, oven drying is *not* recommended for sulfured fruits because of the objectionable odor of the sulfur fumes.

Packaging dried fruits is also similar to packaging dried vegetables. Follow the suggestions given in this publication for vegetables on page 3.

NOTE: Sulfuring does *not* prevent insect infestations, so pack the dried product immediately just as you would unsulfured fruit.

Another point to remember with sulfured fruit: Do not use metal lids unless a cellophane or polyethylene sheet is placed under the lid to prevent sulfur fumes from reacting with the lid.

Storing in plastic bags, tightly sealed, will help keep the original fruit color.

SOME DRIED FOOD SPECIALTIES

FRUIT LEATHERS

Sometimes called fruit rolls or fruit taffies, these "leathers" can be eaten as is, or they

can be made into a beverage by adding 5 parts of water to 1 part leather in a food blender. They can also be used in pie filling, in cooking, and as a topping for dessert.

Any type of fruit can be used: apricots, apples, grapes, berries, pineapple, oranges, pears, peaches, tomatoes, plums, tropical fruits, and others.

Not usually suitable are grapefruit, lemons, persimmons, and rhubarb—without certain modifications.

Preparation

1. Select ripe or overripe fruit.
2. Remove stones or pits from fruit. Seeds of berries or grapes need not be removed. Peel or not, depending upon individual preference.
3. Cut fruit into chunks and place it in a food chopper or mechanical blender.
4. To yellow or light-colored fruit, add 1 tablespoon of lemon or lime juice (2 tablespoons of Meyer variety lemon juice) for each quart of fruit.
5. Chop, grind, or blend until a thick puree is formed.
6. Add 2 tablespoons of sugar per quart to orange and pineapple pulp. (Additional sugar is not needed for other fruits.)
7. Line a cookie sheet or similar flat tray with saran, coated saran, or waxed paper. Make sure that the cookie sheet or tray has an edge to prevent spillage of the puree.
8. Pour the puree onto the sheet or tray about $\frac{1}{4}$ inch deep. Distribute evenly by tilting the tray; do not use a spatula or knife. When all spaces are covered, the right amount of puree has been applied.

Sun drying

This will take from two to three days depending upon temperature and humidity. Test frequently for dryness.

If the weather is hot (above 85° F) and dry (less than 60 percent relative humidity), the trays can be placed in direct sunlight or behind a pane of glass or plexi-glass to concentrate the heat. Cover or bring inside at night if the nighttime temperatures vary more than 20° F from daytime temperatures or if fog or humidity is common at night.

Oven drying

Set oven at lowest setting (140° F). Place the sheets or trays in the oven and leave the oven door cracked open—2 to 6 inches, depending on the oven door. The fruit leather will be dried in 4 to 5 hours.

Dehydrator drying

Place sheets or trays in the dehydrator. Set temperature control at 140° F. Dry for 4 to 5 hours and test for dryness.

Testing for dryness

Properly dried fruit leather will be sticky to the touch, but will be easily peeled from the saran, coated saran, or waxed paper. Lift the edge, which will adhere tightly to the surface, and peel it back about an inch. If it peels readily, it is properly dried.

Storage

After loosening the edge and peeling it back about an inch, roll the saran, coated saran, or waxed paper and the dried leather in one piece in a loose roll.

The dried fruit roll can be stored for years in the freezer, for months in the refrigerator, and for up to 30 weeks at room temperature (70° F or less).

BEEF JERKY

Preparation

1. Slice 5 pounds lean beef (flank steak or similar cut) into strips $\frac{1}{4}$ to $\frac{1}{2}$ inch thick, 1 to 1 $\frac{1}{2}$ inches wide, and 4 to 12 inches long. Cut with grain of meat; remove the fat.
2. Lay out in a single layer on a smooth clean surface (use cutting board, counter, bread board or cookie sheet. Wash wooden surface after use.)
3. If smoke flavor is desired, brush each strip of meat with $\frac{1}{2}$ teaspoon liquid smoke in 2 tablespoons water. Sprinkle strips liberally with salt on both sides. Add pepper to taste and garlic salt or powder if desired.
4. Place strips, layer on layer, in a large wooden bowl or crock and place a plate with a weight on top.
5. Let stand for 6 to 12 hours.
6. Remove strips and blot dry with clean paper toweling.

Other flavors. Instead of the garlic-smoke treatment, you may brush or marinate the strips before drying in such mixtures as teriyaki sauce, sweet and sour sauce, soy sauce, hot chili sauce, or Worcestershire sauce—or combinations of these according to your choice.

Oven drying

Remove racks from oven and stretch meat strips across the racks. Allow the edges of the meat strips to touch, but not overlap. Leave enough space free on the racks for air to circulate in the oven.

Set the temperature at 140° F and let strips dry for about 11 hours. Check early in the drying process for excessive drip. This drip

can be caught on aluminum foil on a rack placed near the bottom of the oven. Lower the temperature of the oven until it feels warm, but does not cook the meat.

Keeping the oven door ajar will facilitate drying, as will the use of an electric fan placed in front of the open oven door.

Dehydrator drying

Follow instructions as you would for fruit or vegetables.

Air or sun drying

An open barbecue with a grill suspended over the charcoal container—or a comparable arrangement may be used for this method.

Line the bottom of the barbecue with aluminum foil to reflect the sun. Stretch strips of meat over the grill. Place in the sun and allow the meat to dry for 4 to 6 days, depending upon the temperature, your storage method, and how long you intend to store it. If the nights are cool, place the barbecue under cover (for example, in the garage) at night to reduce condensation of moisture on the meat. If the barbecue has a cover, you may use this. The strips of meat can also be strung on wire, fishing line, or strong, thin string. Insert a small button between each strip to prevent touching.

Place in a sunny area and dry for several days. Jerky is properly dry when it is chewy and leathery. If brittle, it is too dry.

Storage

Finished jerky can be stored at room temperature in air tight containers, if the jerky is dry enough. With moister jerky, it can be placed in plastic bags and frozen. If there is too much moisture it will become moldy. If fat is excessive, it will turn rancid more rapidly.

SALMON JERKY

Slice salmon filets into thin strips. Salt fish in a dish or enamelled pan using 2 tablespoons salt per pound. Place in a refrigerator for 12 hours. Remove from the refrigerator, and place strips on a rack in the oven to dry. Set the oven to 140° F and allow to dehydrate for 3 to 5 hours.

The salmon strips may also be dried in the sun or on the barbecue (see jerky recipe). This process takes about 3 days. The meat should be brought in at night to prevent moisture condensation.

HOW TO CONSTRUCT A NATURAL-DRAFT DEHYDRATOR FOR HOME USE

This 4-foot high wooden box is especially designed to be placed over a central heat source that dehydrates vegetables as a means to preserve them. About 7 to 9 pounds of prepared leafy vegetables or about 14 pounds of non-leafy vegetables, arranged on slatted, removable trays, are dried with hot air that is circulated evenly with the help of a heat

spreader (sheet iron) suspended from inside the top of the box. (See drawings, pages 11 and 12.)

Materials

Use clean, dry wood that is free from pitch. Plywood or other types of composition board

may be used, but do not use yellow pine.

Stainless steel hardware cloth (often available only in large amounts) may be used for tray bottoms instead of wooden slats.

Do not use galvanized screen; it will impart a metallic taste, discolor the vegetables, and may be toxic (poisonous) when acid foods are dried.

Side posts. Four pieces — 1" x 2" x 4'

Framing for side panels. Four pieces — 1" x 2" x 48", and two pieces — 1" x 2" x 27" (actual dimensions are 3/4" x 1-1/2")

Front braces. Two pieces — 1" x 2" x 15-3/4" (actual dimensions are 3/4" x 1-1/2")

Sides, back, and door. One sheet — 3/8" x 8' plywood

Tray runways. Use non-resinous wood; 14 pieces — 1" x 1" x 2' (actual dimensions are 3/4" x 3/4" x 2')

Tray frames. Use non-resinous wood; 12 pieces — 1/2" x 1" x 8' (actual dimensions are 1/2" x 3/4" x 8')

Tray bottoms. Wooden slats, 1-1/2" x 1/4" placed 1/2" apart, or stainless steel hardware cloth, 1/8" or 1/4" mesh, cut to fit trays

Hardware. One small door hook, two hinges, 2-1/2" size; 1/2" and 1" long nails for trays; eight 2-1/2" No. 8 flat wood screws; 16 1-1/2" No. 8 flat head wood screws

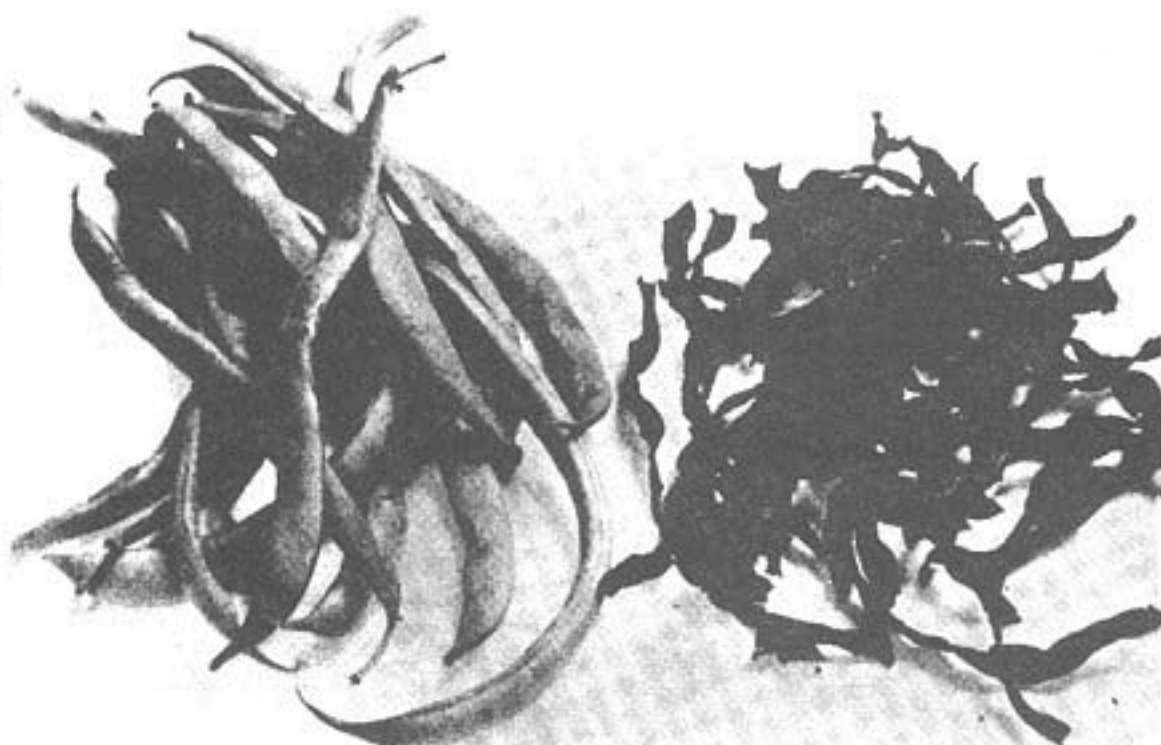
Heat source. An electric or gas heater — or electric or gas plate (1,100 watts)

Sheet metal. 16-gauge or thicker, 12" x 18", plus four pieces of wire 8" long and four screw eyes for hanging heat spreader

Construction (See drawings, pages 11 and 12.)

Sides. Cut two pieces 30" x 48" from plywood. Nail and glue 1" x 2" boards along the top and sides.

Tray runways. To each side, nail one tray runway of 1" x 30", 5" from the top. Place remain-



Fresh green beans (left) and dried green beans (right). Beans are blanched 2 minutes in boiling water and dried in a dehydrator.

ing six runways 3-1/2" apart, measuring from the top of one runway to the top of the next.

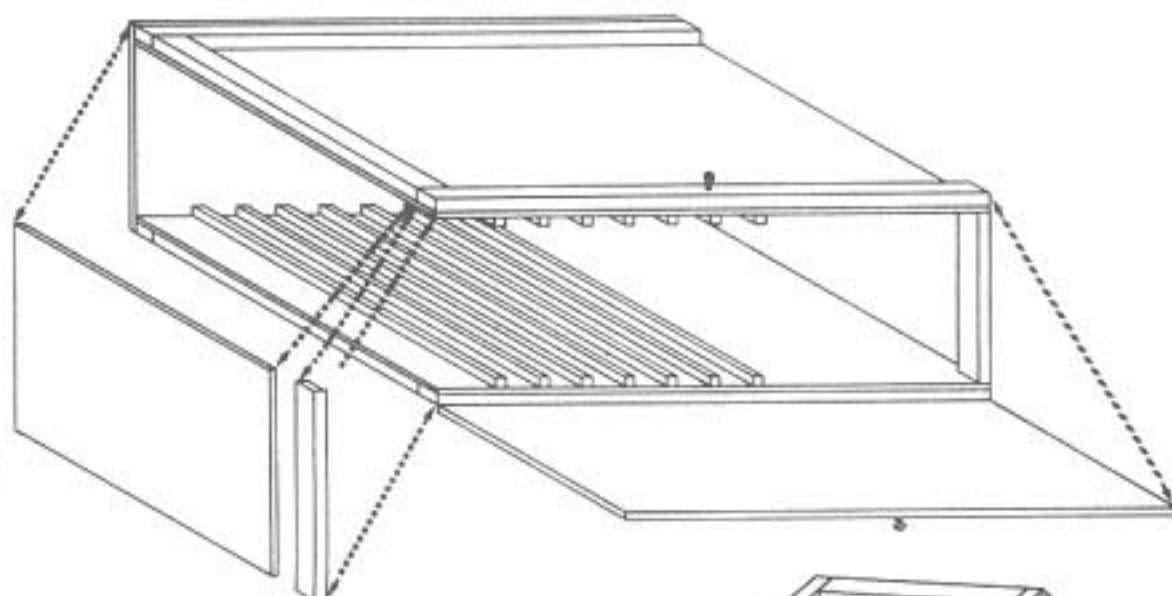
Rear wall. Cut plywood 18" x 48" and fasten to side panels with eight 1-1/4" screws.

Front of dryer. Fasten front braces between side panels—one of them flush with top of dryer and

Door.

the other flush with bottom. Use eight 1-1/2" screws. Unit is fastened with screws so that it can be disassembled for storage.

Cut plywood 18" x 44". Fasten to front with hinges and hook. Position door so that it is flush with top of dryer and attach it to left-side panel with hinges. The



Exploded view of a natural draft dehydrator.



open space at bottom provides the air intake.

Top.

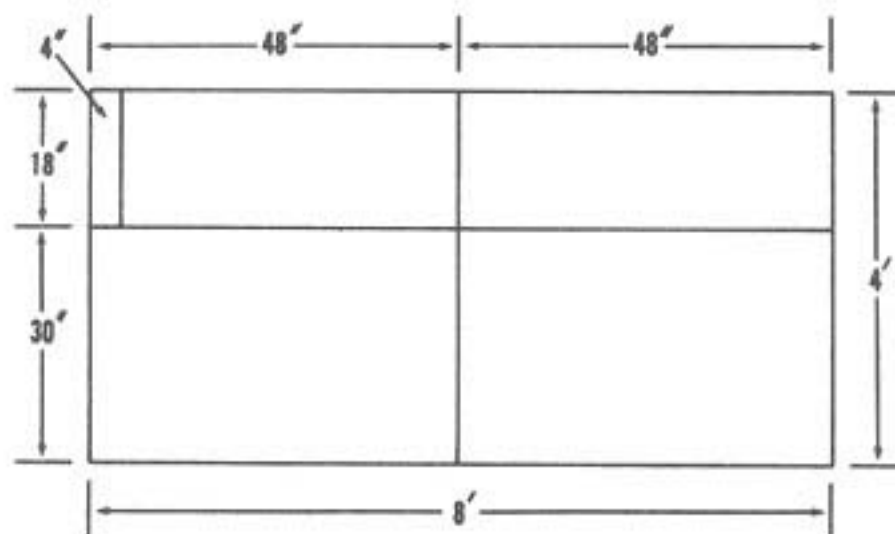
Cut two pieces of plywood 18" x 23-3/4" and 18" x 4". Fasten large piece to back and top edge of dryer with 1-1/2" screws. Fasten smaller piece across the top at the front leaving 3" slot between the two top pieces to let the moist air escape.

Trays.

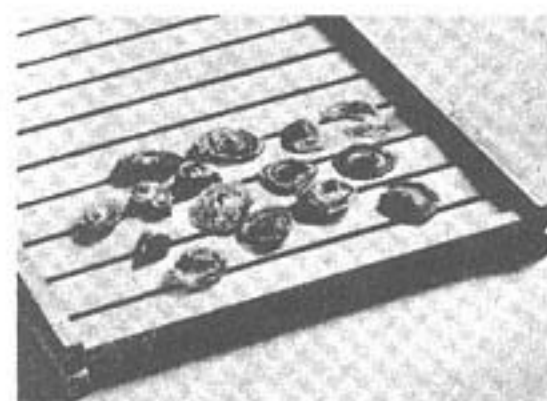
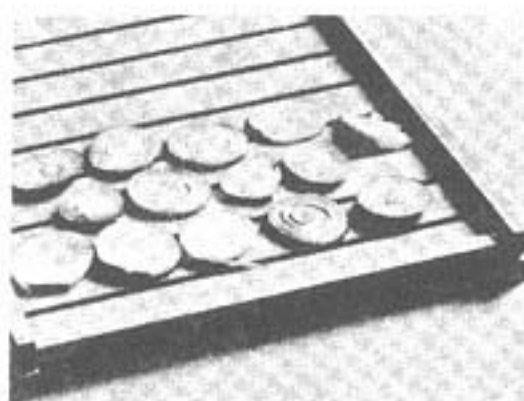
Cut 28 pieces of lumber, 1/2" x 1" x 24". Cut 28 pieces 1/2" x 1" x 13-3/4", for frames. For each tray, place two pieces of each length together to form a rectangle to measure 15-1/4" x 24" overall. Space and nail 12-1/4" by 1-1/2" x 15-1/4" slats on this frame. Nail four similar strips on top of the slats. If stainless steel hardware cloth is used, tack it in place on the tray frames.

Heat spreader.

On sides of dehydrator, inside, locate screw eyes so that you can suspend heat spreader to hang 2" above heat source.



Exploded view of a drying tray. Construction details are given on page 10.



Fresh onion slices (left) and dried onion slices (right). Onions were not blanched and were dried in a dehydrator.

GUARD AGAINST FIRE

If a flame or unprotected electric coil is used, line the edges of the air intake and the interior nearest the heat with asbestos board. Place an asbestos board or a metal plate under the heat source.

Heat spreader

On the inside of the top, use wire and screw eyes to suspend the heat spreader 2" above the heat source for air circulation.



How To Build a Portable Electric Food Dehydrator

Dale E. Kirk

Agricultural Engineer, Oregon State University

*Oregon State University Extension Service Circular 855.

A small dehydrator can be used in the home to preserve many types of fruits, blanched vegetables, meats, and nuts and to make specialty confections from fresh, natural products.

The dehydrator shown in Figure 1 and de-

Table 1. Home Drying of Vegetables

For oven and portable dehydrators, set temperatures at 140° F.
Sun drying requires temperatures of 98° to 100° F.

Vegetable	Preparation	Blanching		Drying	
		Method	Time minutes	Method	Time hours
Artichoke, globe	Cut hearts into 1/8 inch strips.	Heat in boiling solution (3/4 cup water, 1 tbs. lemon juice.)	6 - 8	dehydrator.....	12 - 16
Asparagus	Wash thoroughly. Halve large tips.	Steam.....	4 - 5	oven.....	4 - 7
		Water.....	3% - 4%	sun.....	10 - 12
Beans, green	Wash thoroughly. Cut in short pieces or lengthwise.	Steam.....	2 - 2%	dehydrator.....	6 - 10
		Water.....	2	oven.....	3 - 4
				sun.....	8 - 10
Beets	Cook as usual. Cool; peel. Cut into shoestring strips 1/8 inch thick.	Already cooked; no further blanching required.	—	dehydrator.....	8 - 14
				oven.....	3 - 5
				sun.....	8 - 10
Broccoli	Trim, cut as for serving. Wash thoroughly. Quarter stalks lengthwise.	Steam.....	3 - 3%	dehydrator.....	12 - 15
		Water.....	2	oven.....	3 - 4%
				sun.....	8 - 10
Brussels sprouts	Cut in half lengthwise through stem.	Steam.....	6 - 7	dehydrator.....	12 - 18
		Water.....	4% - 5%	oven.....	4 - 5
				sun.....	9 - 11
Cabbage	Remove outer leaves; quarter and core. Cut into strips 1/8 inch thick.	Steam until wilted....	2% - 3	dehydrator.....	10 - 12
		Water.....	1% - 2	oven.....	1 - 3
				sun.....	6 - 7
Carrots	Use only crisp, tender carrots. Wash thoroughly. Cut off roots and tops; preferably peel, cut in slices or strips 1/8 inch thick.	Steam.....	3 - 3%	dehydrator.....	10 - 12
		Water.....	3%	oven.....	3% - 5
				sun.....	8
Cauliflower	Prepare as for serving.	Steam.....	4 - 5	dehydrator.....	12 - 15
		Water.....	3 - 4	oven.....	4 - 6
				sun.....	8 - 11

scribed in the drawings in Figure 2 provides 8½ square feet of tray surface, which can accommodate approximately 18 pounds of fresh, moist product. The necessary heat for evaporating the moisture is supplied by standard household light bulbs, which are efficient and relatively safe heating elements. An 8-inch household type electric fan can be used for air circulation, or a 6-inch or 8-inch-diameter air-duct circulating fan may be purchased from an electrical supply house.

The dehydrator box described here is easy to build. It requires only two forms of wood building materials: ½-inch plywood and ¾-inch square wood strips. The necessary lumber and electrical supplies are shown in Figure 3. Construction can be done with a hand saw, a coping saw or compass saw, drill, countersink, screwdriver, and knife. A square or tape is needed for measurements.

The drying trays may be built of wooden slats or metal mesh. We recommend, however, that you purchase prefabricated aluminum window screens for use as trays. They are light weight, sturdy, easily cleaned, and relieve the builder of much of the more difficult construction.

Construction Materials

You'll need these materials to build the dehydrator described:

- 1 sheet of ½-inch, 4 x 8 foot, A-C exterior plywood
- 9 4 foot pieces of 1 x 1-inch nominal (¾ x ¾-inch actual) wood strips
- 1 8-inch fan
- 1 set of 5 aluminum screens for trays, 16½ x 20, 16½ x 19, 16½ x 17½, 16½ x 16½, and 16½ x 15½ inches
- 1 pair of 2-inch, metal butt hinges
- 1 ball chain or equivalent door latch
- 9 porcelain surface-mount sockets
- 9 75-watt light bulbs
- 15 feet of asbestos-covered #14 copper wire
- 6 feet of #14 wire extension cord, with male plug
- 1 36-inch length of heavy-duty household aluminum foil wrap
- 116 1-inch No. 8 flathead wood screws (nails and glue may be used instead)
- 18 ¾-inch x No. 7 roundhead wood or sheet-metal screws
- 1 10-amp-capacity thermostat, 100-160° F approximate range
- 1 4-inch electrical surface utility box with blank cover
- 2 ½-inch utility box compression fittings
- 2 wire nuts

Cutting and Assembly

The cutting diagram in Figure 4 shows how all of the ½-inch plywood pieces can be cut from the single 4 x 8-foot sheet. It is usually most satisfactory to measure from the factory-cut edges as shown. Allowances for saw kerfs must be made between adjacent pieces.

Cut the plywood sections to size and the 1 x 4 strips to the lengths shown. Then assemble the side panels as shown in Figure 5.

Next, lay out the porcelain sockets and fasten to the base, as shown in Figure 6. Fasten the asbestos covered wire to the porcelain sockets. Connect the wire that goes to the yellow screws on the sockets to the thermostat, mounted near the rear on the left side panel. (The yellow screws on the sockets connect to the center pole, rather than the threaded wall of the socket.) Connect the wire that goes to the white screws to the white wire in the extension cord. The third wire (green) in the extension cord should be connected directly to the

Celery	Trim stalks. Wash stalks and leaves thoroughly. Slice stalks.	Steam..... 2 Water..... 2	dehydrator..... 10 -16 oven..... 3 - 4 sun..... 8
Corn on the cob	Husk, trim.	Steam until milk does not exude from kernel when cut..... 2 - 2½ Water..... 1½	dehydrator..... 12 -15 oven..... 4 - 6 sun..... 8
Corn, cut	Prepare in the same manner as corn on the cob, except cut the kernels from the cob after blanching.		dehydrator..... 6 -10 oven..... 2 - 3 sun..... 6
Egg plant	Use the same directions as for summer squash.	Steam..... 3½ Water..... 3	dehydrator..... 12 -14 oven..... 3½ - 5 sun..... 6 - 8
Horseradish	Wash; remove small rootlets and stubs. Peel or scrape roots. Grate or cut into 1/8-inch slices.	None	dehydrator..... 4 -10 oven..... 3 - 4 sun..... 7 -10
Mushrooms (WARNING: see below)†	Scrub thoroughly. Discard any tough, woody stalks. Cut tender stalks into short sections. Do not peel small mushrooms or "buttons." Peel large mushrooms, slice.	None	dehydrator..... 8 -10 oven..... 3 - 5 sun..... 6 - 8
Okra	Wash, trim, slice crosswise in 1/8 - 1/4 inch disks.	None	dehydrator..... 8 -10 oven..... 4 - 6 sun..... 8 -11
Onions	Wash, remove outer "paper shells." Remove tops and root ends, slice 1/8 - 1/4 inch thick.	None	dehydrator..... 10 -20 oven..... 3 - 6 sun..... 8 -11
Parsley	Wash thoroughly. Separate clusters. Discard long or tough stems.	None	dehydrator..... 1 - 2 oven..... 2 - 4 sun..... 6 - 8
Peas	Shell.	Steam..... 3 Water..... 2	dehydrator..... 8 -10 oven..... 3 sun..... 6 - 8
Peppers and pimientos	Wash, stem, core. Remove "partitions." Cut into disks about 3/8 by 3/8 inch.	None	dehydrator..... 8 -12 oven..... 2½ - 5 sun..... 6 - 8
Potatoes	Wash, peel. Cut into shoe-string strips 1/4 inch thick, or cut in slices 1/8 inch thick.	Steam..... 6 - 8 Water..... 5 - 6	dehydrator..... 8 -12 oven..... 4 - 6 sun..... 8 -11
Spinach and other greens (kale, chard, mustard)	Trim, wash very thoroughly.	Steam until thoroughly wilted..... 2 - 2½ Water..... 1½	dehydrator..... 8 -10 oven..... 2½ - 3½ sun..... 6 - 8
Squash: Banana	Wash, peel, slice in strips about 1/4 inch thick.	Steam..... 2½ - 3 Water..... 1	dehydrator..... 10 -16 oven..... 4 - 5 sun..... 6 - 8
Hubbard	Cut or break into pieces. Remove seeds and cavity pulp. Cut into 1 inch wide strips. Peel rind. Cut strips crosswise into pieces about 1/8 inch thick.	Steam..... 2½ - 3 Water..... 1	dehydrator..... 10 -16 oven..... 4 - 5 sun..... 6 - 8
Summer	Wash, trim, cut into 1/4 inch slices.	Steam..... 2½ - 3 Water..... 1½	dehydrator..... 10 -12 oven..... 4 - 6 sun..... 6 - 8
Tomatoes, for stewing	Steam or dip in boiling water to loosen skins. Chill in cold water. Peel. Cut into sections about 3/4 inch wide, or slice. Cut small pear or plum tomatoes in half.	Steam..... 3 Water..... 1	dehydrator..... 10 -18 oven..... 6 - 8 sun..... 8 -10

* Preferred method.

† WARNING: The toxins of poisonous varieties of mushrooms are not destroyed by drying or by cooking. Only an expert can differentiate between poisonous and edible varieties.

junction box, mounted on the front panel.

If you use a household-type fan with the base left attached, fasten it in place on the dehydrator base and cut the hole in the fan bulkhead to fit. If you use a duct-type fan, cut the necessary size hole

(approximately 8½ inches in diameter for an 8-inch fan or approximately 6½ inches in diameter for a 6-inch fan) in the bulkhead and fasten the fan-mounting frame directly to the bulkhead. Now set the bulkhead in place (approximately 5 to 5½

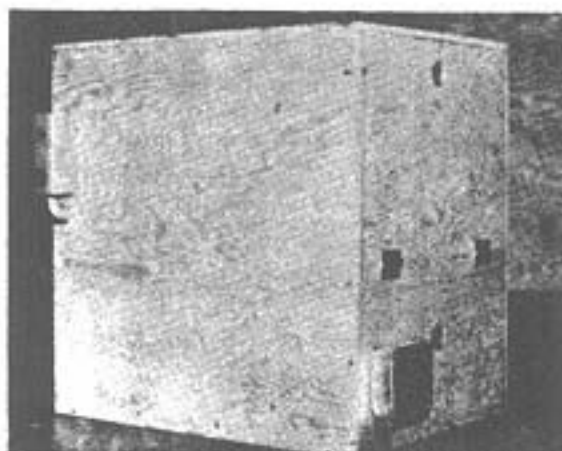


Figure 1. Table top size food dehydrator for home use. inches from the front panel) and fasten it temporarily in position by two screws through the left side panel as shown in Figure 7. Center the 1½-inch-diameter air vent hole in the front panel directly in front of the fan motor, approximately one inch away from the motor. This will allow the cold air to enter and pass over the motor to cool it.

Next, fasten the right side, back, and top in place.

Cover the heat shield with a heavy-duty household aluminum foil wrap. This provides a reflective surface to protect the plywood heat shield,

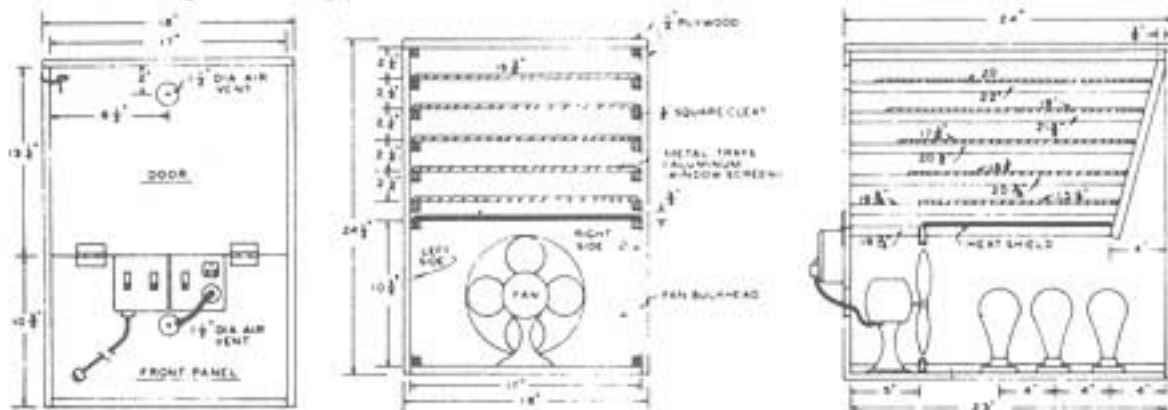


Figure 2. Front and two section views of dehydrator construction.

and also provides a smooth surface on the top of the shield for easier removal of juices that may drip from the drying trays.

You could build the drying trays, but we suggest you purchase aluminum window screens made to the sizes listed. You can order these through your local lumber or building supply dealer in Oregon. If they do not have a ready source of sup-

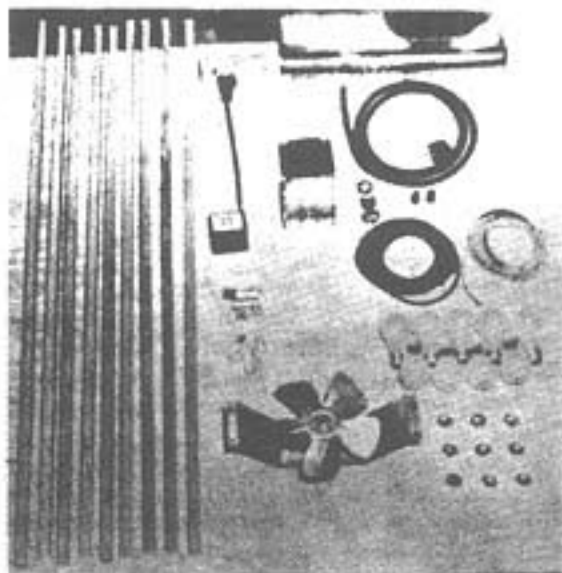


Figure 3. Materials needed for construction.

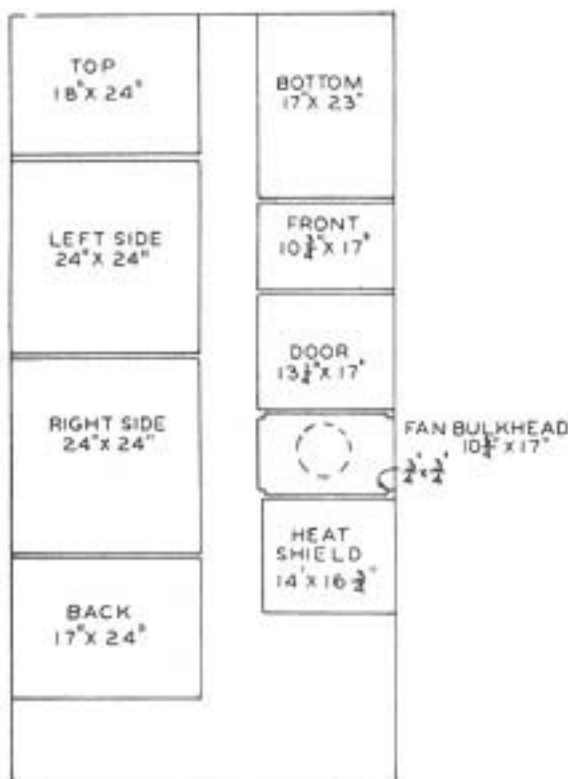


Figure 4. Cutting plan to obtain the necessary plywood parts with a minimum of saw cuts.

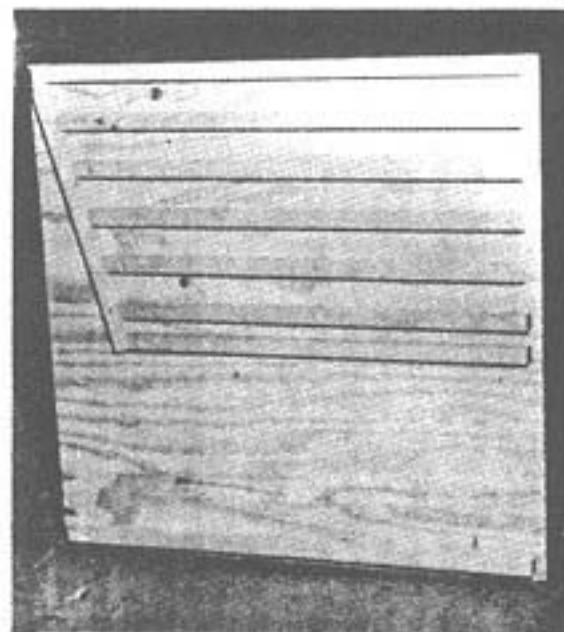


Figure 5. Right side panel showing cleats assembled to the inside surface.

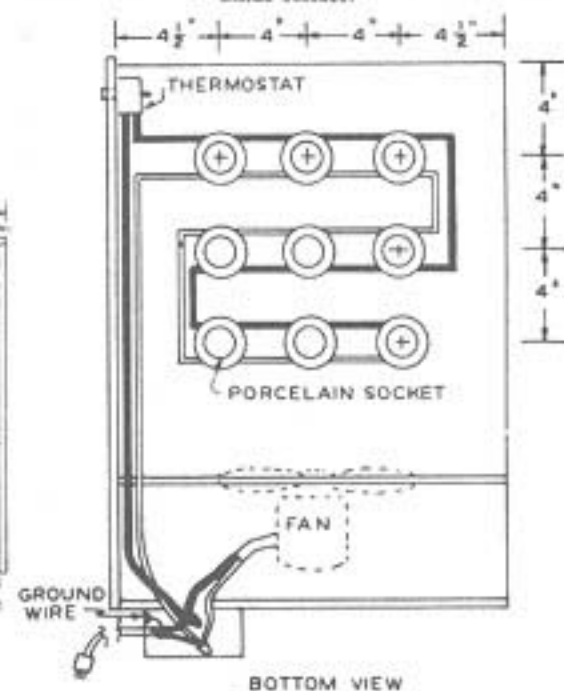


Figure 6. Layout of socket locations and wiring plan.

pounds of fresh product per square foot of tray surface. The door may be kept closed for the first 30 minutes to 60 minutes to bring the product and the dehydrator box up to the desired drying tem-

ply, further information about suppliers may be obtained through your local county Extension office. If you prefer to build the trays, we suggest you make a light wooden frame and use either aluminum screen or galvanized hardware cloth. Most plastic screens will sag badly under load and heat. Black-metal screens will rust and leave stains on the food product.

You'll need some type of adjustable latch to hold the door in a partially opened position during the early stages of drying, when the moisture is being removed rapidly. The ball-link chain with a catch as shown provides a ready adjustment for the amount of door opening.

As a check on the thermostat setting, some type of thermometer capable of service in the 100 to 160° F temperature range should be available. The dial type, as shown in Figure 8, is rugged and easily read. A kitchen-type meat thermometer also will serve. The sensing part of the thermometer should project through the box into the space above the trays for accurate indication of the drying temperature. Placing the sensing element in the heating chamber with the light bulbs will give a misleading, high reading.

Operation

For most moist fruits and blanched vegetables the trays may be loaded at the rate of one to two



Figure 7. Bottom, front, left side, and bulkhead assembled with sockets, fan, wiring, and thermostat in place. Note projection of the thermostat sensing element into the space behind the trays.



Figure 8. Dial type thermometer useful in monitoring dehydrator temperature.

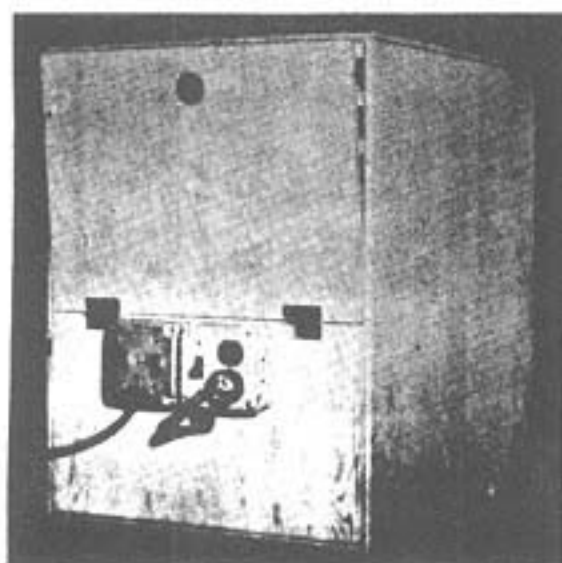


Figure 9. Dehydrator cabinet showing three switches used to control heat input. Note the use of a duplex outlet which may be used for plugging in the fan instead of wiring in permanently.

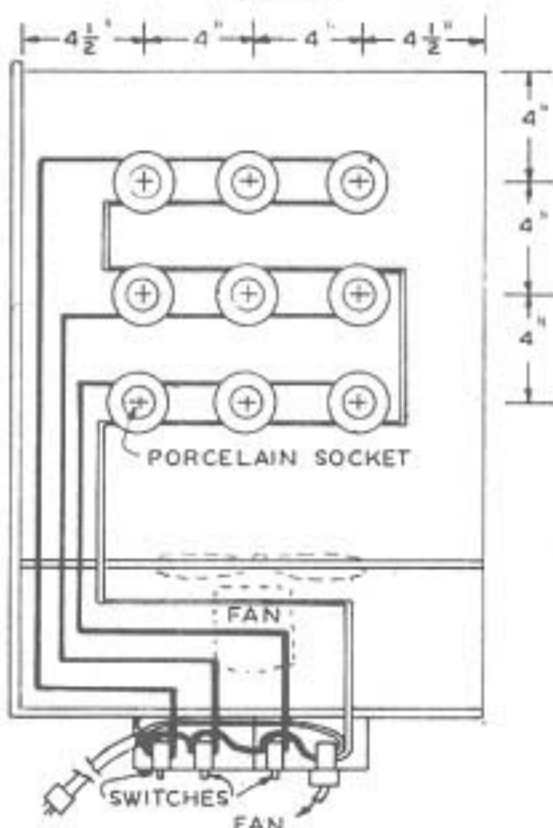


Figure 10. Socket location layout and wiring plan for use with three-switch control.

perature. Once this temperature is reached, the door should be opened about $\frac{1}{8}$ to $\frac{1}{4}$ inch at the top to allow easier escape of the moisture-laden air. The moist air will exhaust at the top and additional fresh air will be taken in along the sides of the partially opened door.

Fruit	Preparation	Treat before drying. Choose one of the following three methods.			Drying times		Test for dryness (Cool before testing)
		Sulfur	Steam blanch	Water blanch	Sun drying	Dehydra- tor	
Apples	Peeled and core, cut into slices or rings about $\frac{1}{8}$ thick.	45 minutes	5 minutes, depending on texture	—	3-4 days	6-12 hours	Soft, pliable, no moist area in center when cut.
Apricots	Pit and halve for steam blanch or sulfuring. Leave whole for water blanch. Pit and halve after blanch.	2 hours	3-4 minutes	4-5 minutes	2-3 days	24-36** hours	Same as for apples
Figs	In dry, warm, sunny climates, it is preferable to partly dry on the tree. Figs normally drop from the tree when $\frac{2}{3}$ dry. In coastal areas, pick fruit when ripe.	No treatment necessary			4-5 days	12-20 hours	Flesh pliable, slightly sticky, but not wet
Grapes: Muscat, Tokay, or any seedless grape	Leave whole. Grapes dry in less time if dipped in lye 10 seconds.* Or blanch $\frac{1}{2}$ to 1 minute.	No treatment necessary			3-5 days	12-20 hours	Raisin-like texture, no moist center
Nectarines and peaches	When sulfuring, pit and halve; if desired, remove skins. For steam and water blanching, leave whole, then pit and halve.	2-3 hours	8 minutes	8 minutes	3-5 days	36-48** hours	Same as for apples
Pears	Cut in half and core. Peeling preferred.	5 hours	6 minutes (peeled, will be soft)	—	5 days	24-36** hours	Same as for apples
Persimmons	Use firm fruit when using the long, softer variety, and use riper fruit when using the round, drier variety. Peel and slice with stainless steel knife.	No treatment necessary			5-6 days	18-24 hours	Light to medium brown, tender, but not sticky
Prunes	For sun-drying, dip in boiling lye solution* or blanch in boiling water or steam for 1 to 1- $\frac{1}{2}$ minutes, to "check" skins. For oven-drying, rinse in hot tap-water. Leave whole. If sulfuring, pit and halve.	No treatment necessary. However, sulfuring for one hour will produce good flavor.			4-5 days (3-4 days when using lye.)	24-36 hours	Leathery; pit should not slip when squeezed if prune not cut.

*See page 534 for making a lye solution.

**Drying times can be shortened by cutting fruit into slices

Test to see when the first, high-moisture stage is over. Hold your hand at the opening at the top of the door.

When moisture no longer tends to condense on your hand or on your metal watch band, close the door. The air exchange provided by the two 1 $\frac{1}{2}$ -inch-diameter vents should be enough to complete the drying process.

Maintenance

The electric fan motor is supplied by a stream of fresh air from the lower vent, positioned in front of the motor, but it will still operate at a higher temperature than in normal, open-room service. Lubricate the motor bearings with 30-weight engine oil. Lighter grade household or sewing machine oil may tend to gum and stall the fan motor after extended service.

Wash trays with hot water and a detergent when they become soiled with dried-on juices. If you purchased the recommended aluminum win-

dow screens with an aluminum wedge strip to hold the screen in place, you can put them in an electric dishwasher without damage.

Alternate Construction and Operation

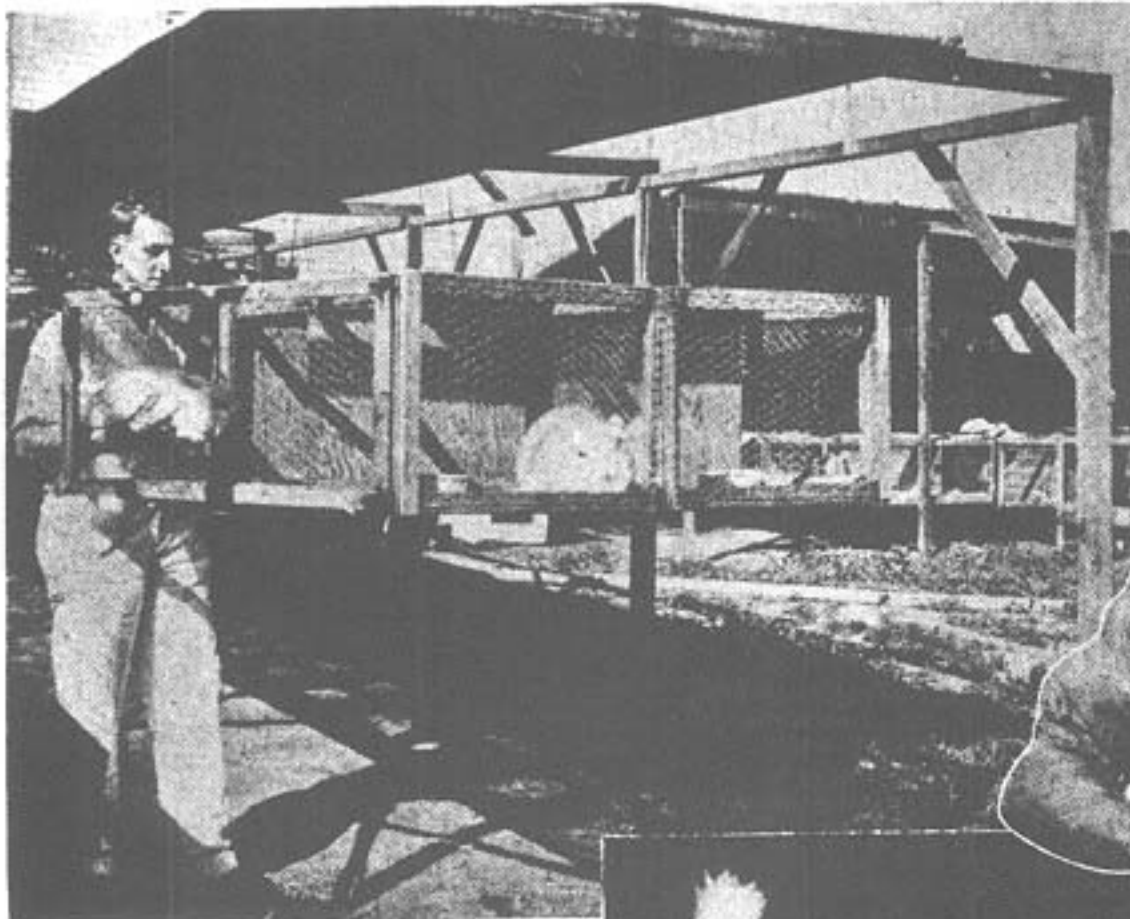
The dehydrator can be built without a thermostat. Temperature can be controlled by the use of switches to operate various numbers of light bulbs. Figure 9 shows such a unit, with three separate switches, each controlling three bulbs in the heating chamber. The wiring diagram is shown in Figure 10.

All three switches should be turned on for at least the first hour or two when the dehydrator is loaded with moist product. As soon as the temperature comes up to the desired level and the extra heat is not needed to warm large amounts of incoming fresh air, one or two switches may be turned off and the drying completed at the reduced heating rate. □

Raise Your Own Wool on a Back-Yard Rabbit Ranch

By

JOHN E. LODGE



When space is available, single-tier hutches like these produce larger rabbits and better yields of wool. They are suspended from above.

Popular Science, March 1937

IN THE small quarters of your own back yard, you can grow mother's fur coat, sister's knitted suit, and brother's sweater, with a pair of warm socks left over for dad.

With two dozen Angora rabbits you can produce enough wool to supply the family with the finest knitted garments the market affords; and from the progeny of your first stock, you can secure fine pelts for neck pieces and coats which rival in beauty the most costly to be had anywhere.

Tan your own skins, spin and dye your own yarn. Methods are simple and inexpensive. It's the newest thing in fur farming, too. Three years ago, Angora rabbits were little known in the United States. Today there are 300 professional growers in southern California alone. Countless amateurs, particularly on the Pacific coast, are producing their own garments from these sons and daughters of Asia.

Let's suppose you are interested in Angoras and have decided to try your hand



at growing these fine animals, both for pelts and wool. How much need you invest; how much room do you require; how may you turn the skins and wool to practical account?

At the outset, you should acquire your stock with considerable care, for many white rabbits are "woolly" without being Angoras. If you select animals that are well tufted on the ears, with short bodies, heads broad and well furnished, and feet and bodies generally well-wooled, you can't go wrong. As a further test, cut off some wool and throw it into the air. If it floats, rather than sinks heavily, you can be assured that the rabbit is an Angora.

You need no more than four does and one male to start your back-yard wool



In clipping, part the wool along the back and work forward and down, using blunt-nose, sharp scissors. Your clipped rabbit should look like the one shown at the left, with hair on face, ears, feet, and tail untouched.

farm. Thereafter, you may breed the does every ninety days. Keep only the four strongest from each litter, for they not only will grow more rapidly but will attain more total weight than a larger number. Thirty dollars will cover the initial costs, including both stock and breeding hutch, and you need a plot no larger than twenty feet square.

An ideal breeding hutch is forty-eight by thirty inches, and eighteen inches high, with one-half to five-eighths-inch hardware cloth (coarse wire screen) for the floor and one-inch mesh

chicken wire for the sides, provided the hutch is sheltered from the weather. If it is outdoors, put on a roof with six to eight-inch slopes, with the front edge of the roof extending out eighteen inches. Cover the roof with tar paper. Construct back and sides from half-inch boards. Face the hutch south for coolness in summer and for warmth in winter. Suggestions for the

design of hutches, feeders, nest boxes, and runways can be obtained from the breeders' associations and from state or Federal agricultural agencies.

Since you are creating wool, not flesh, the Angora's diet will vary slightly from that given other rabbits. Give each two feedings a day, alfalfa in the morning, red oats or barley in the evening, for a total of two and a half ounces. It is better to use cut, dry alfalfa, of good quality only, to avoid scours or bloat.

If you do not feed too heavily, the rabbit will clean up his meal in twenty minutes. Should he leave any of his food, the chances are that he is suffering from wool block in the intestines. To remove the block, give the rabbit one teaspoonful of mineral oil. If he is subject to block, apply this remedy once a week. Should he not respond, and appear feverish, give two tablespoons of epsom salts and place him on the ground where he can exercise, giving a vegetable diet for three or four days. This treatment usually will bring him around.

When ready to clip, place the Angora on a stand or stool with a top just large enough to permit the animal to sit without turning around. Brush thoroughly, using a stiff bristle brush, taking care to clean out all foreign matter. Part the wool down the center of the back. With an ordinary pair of well-sharpened, blunt-pointed scissors, start from the rear and work forward, taking sections down and around the animal. Insert the lower jaw of the scissors near the end of the part and clip down this line, holding the upper part about half an inch from the animal's hide.

As you proceed, take care to separate the various grades of wool by length. This is particularly important, since the longer wool is worth about ten times as much as that in which long and short hairs are mixed.

Continue clipping until you have finished one side, turn the animal over and clip the opposite side, then the rump. Be very careful in clipping near the tail or you may cause an injury.

If you have been clipping a breeding doe, you have now finished your task. Bucks and young stock, however, may also be clipped on the belly and breast. To accomplish this,



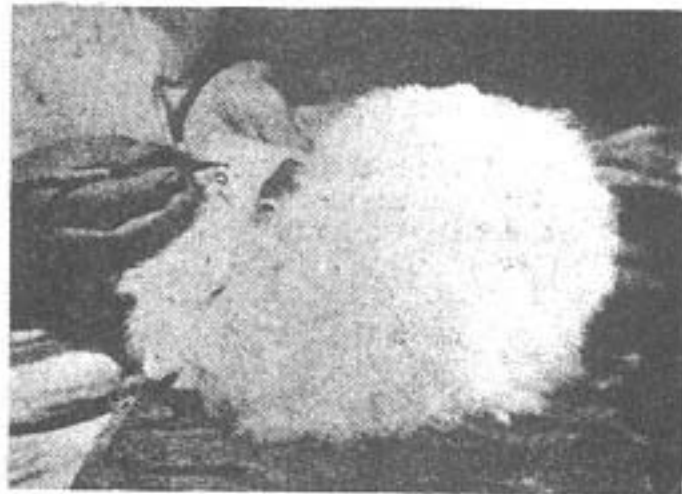
The woman in the picture above is wearing knit garments made from rabbit wool, and a fur piece from pelts. Right, spinning wool on a Swedish-type wheel to make yarn



place the animal's ears down over the shoulder, pick up gently both the ears and the loose shoulder skin, raise the animal, and rest its rump on the stool. Now proceed to clip, taking the wool first from the breast and then from the belly. If the Angora becomes too active, hold it up by placing the skin of the forehead between your thumb and forefinger. After a little experience, you will find you can clip an Angora in six or seven minutes.

Since the fine wool may suffer from too much handling, place each grade by hand in a separate receptacle. If it is to be stored for any length of time, it is better to use some good moth repellent. Do not press the wool down in the sacks or cans, but lay it in carefully. Tight packing frequently causes webbing, for the wool has a high felting capacity.

The young may be clipped when eight to ten weeks old, and about every nine weeks thereafter, depending on the length of wool you desire. Wool from two to two and a half inches long is worth about four dollars a pound, while that exceeding three inches will bring six dollars. Since an Angora produces, on an average, twelve ounces each year, and some up to twenty-three ounces, it is important to take the



Rabbits can be marked for identification by tattooing the ears with India ink. Here, this is being done with a pencil that has five sharp needles for puncturing the skin

longest wool possible and preserve it in packing and shipping.

Here are a few tips which will help you avoid mixing grades: Never clip ear tufts or furnishings on the face; never clip the wool underneath the feet; never clip over a second time to make your job look better, for this short wool is worthless. With a little experience, you will soon be doing a first-rate job of clipping.

Hand-spinning this fine wool is quite practical as a hobby, and from it you can produce many articles of value, from scarfs to sweaters. The wool also takes dyes nicely, and will retain color from better grades of dye without fading. Use a spinning wheel of the Swedish type, spinning the wool as it is clipped from the rabbit in exactly the same way as sheep's wool

is spun. It is not necessary in hand-spinning to card the wool, as is required in high-speed commercial production of Angora wool yarn.

It is advisable to use raw wool from two to three inches in length. Long wool is easier to work and less apt to shed after spinning. It should be spun in a single strand, then double-twisted. Because it is lighter and warmer than other yarns, this double twist will be found quite heavy enough for sweaters, baby garments, and hosiery; for any garments, in fact, that are ordinarily made from yarn.

Also, you can easily produce fluffy, snow-white pelts for beautiful furs, especially neck pieces, from Angoras. The wool is finer than silk and wears better than most rabbit fur. By feeding properly and giving the animals good care, you will be repaid in the fineness of the fur.

In order to save the pelt, after killing the rabbit, slit down the insides of the legs with a small knife and also about the neck; then, by peeling down the fur over the legs and hind quarters, strip the fur from the body, leaving the flesh side out. Where necessary, use the knife to separate skin from flesh, particularly along the abdomen. A pair of pruning shears will be useful in severing the feet. This is known as a "cased" skin, and is more easily dried and brings a better price than those slit down the front.

SPECIAL wire stretchers may be purchased for stretching cased skins, or you may easily make your own from wire or a board.



On the scales are twelve ounces of wool, the average year's yield from a single animal. Some produce nearly twice as much.

Use either eight or ten-gauge galvanized wire, and bend it around a rod the size of your finger, making a complete loop and leaving twenty-three-inch prongs projecting at the ends slightly out from parallel. A board rounded to shape and fitting the average-size pelt, may be used, but drying will be slower.

Place the pelt, inside out, over the stretcher, legs on one flat side, back on the other. Hang

in a dry place until all moisture has left the skin. This will take about ten days.

It is important to know when the rabbit will yield a good pelt. As a general rule, it will do so at any time except when molting. Molt in the pelt is usually noticed as a break in the ticking. If the pelt shows no ticking, a gentle pull of the fur near the rump may show loose hairs. Blowing into the hair should show new hair at the base near the skin. A dark discoloration of the skin before or after dressing usually indicates molting.

Since the first molt starts when the animal is six to eight weeks old, the pelt will be in good condition previous to this first molt, and will be ready for use again when the rabbit is about six months old. Best furs are taken between October and April from rabbits approaching six months of age. Pelts giving fur about an inch and a half long may be made into beautiful, silky jackets and various fur pieces. Coarse and thin fur should be avoided; likewise, the color of the fur should be uniform and free from hutch or blood stain or sun injury.

IF YOU do not wish to send your fur to a professional tanner, make sure it is well-fleshed at the beginning of the curing process. Place it in a bucket half-filled with water containing a handful of common salt. Leave the skin in the water until it becomes quite soft, then place it on a flat board and with a blunt knife or a pumice stone detach the tissues from the skin, beginning at the hind legs at the edge of the skin. Take care not to tear the skin while removing the tissue.

With the skin thus prepared, you now may make your tanning solution, using four ounces of chrome alum, one and one eighth ounces of ordinary soda, and eight ounces of ordinary dextrine. Place each of these ingredients in a separate twenty-four-ounce bottle, fill each with water, and shake the alum until it has dissolved. Take three ounces from each bottle, adding the soda to the alum, always stirring, then add the dextrine.

Pour twenty-four ounces of cold water into a bucket, add half of the liquid, and place the skins in this solution. Move the skins occasionally to make

sure they are thoroughly saturated. Let them stand twenty-four hours, and add the rest of the solution. The entire nine ounces of tanning liquid is now mixed with the water. Let this stand another twelve hours, but not more than twenty-four, and by that time the skins will be well tanned. After removal, wash the skins thoroughly and place them in a second bucket containing a mixture of chalk and water. Leave them for one hour, then wash the skins in cold water.

Because the pelt has now been softened, it should be worked over a board and wrung out and twisted until it becomes quite dry and pliable. To assure return to its former luster, work in one part of neat's-foot oil to two parts of Castile soap dissolved in water. Following this, the pelt may be hung up in a moderately warm place for drying, after which it may be worked again until all hard spots have disappeared. All traces of grease and dirt should then be removed, which can best be accomplished by placing the skin in a box of fuller's earth and shaking it well several times. After about two hours, remove the skin from the box, shake it well again and brush out all traces of the clay.

BY FOLLOWING the twelve rules below, offered by the University of California College of Agriculture, you will be able to produce finer Angoras at lower cost:

Buy stock from a reliable breeder. If in doubt, inquire of the breeders' associations. Start with only one breed. Do not attempt to mix Angoras with others.

Keep hutches dry, sanitary, free from drafts; provide plenty of sunlight.

Isolate all sick or diseased animals and destroy those which cannot be cured; do not change feeders or dishes from one hutch to another without first disinfecting the equipment.

Use only mature rabbits as breeders and plan to raise four litters to a doe each year.

Use well-built, economical hutches, which will prove inviting to guests and prospective buyers.

Cull out all inferior stock and plan to improve the quality of your animals gradually by using only the best breeders.

Feed regularly and use a well-balanced ration.

Buy feed in quantity at the season when prices are lowest.

Maintain an economical unit and keep costs down.

Do not buy inferior or diseased stock at any price.

Do not keep does that have outlived their usefulness.

RABBIT SKINS, to Cure.—

Lay the skin on a smooth board, the fur side undermost, and fasten it down with tinned tacks. Wash it over first with a solution of salt; then dissolve $2\frac{1}{2}$ ozs. of alum in a pint of warm water, and with a sponge dipped in this solution, moisten the surface all over: repeat this every now and then for three days: when the skin is quite dry, take out the tacks, and rolling it loosely the long way, the hair inside, draw it quickly backwards and forwards through a large smooth ring, until it is quite soft, then roll it in the contrary way of the skin, and repeat the operation. Skins prepared thus are useful for many domestic purposes.

To Preserve Cucumbers.—Take large and fresh-gathered cucumbers; split them down and take out all the seeds, lay them in salt and water, sufficiently strong to bear an egg, for three days; set them on a fire with cold water, and a small lump of alum, and boil them a few minutes, or till tender; drain them, and pour on them a thin syrup:—let them lie two days; boil the syrup again, and put it over the cucumbers; repeat this part of the process a second and a third time: then have ready some fresh clarified sugar, boiled to a *blow* (which may be known by dipping the skimmer into the sugar, and blowing strongly through the holes of it; if little bladders appear, it has attained that degree); put in the cucumbers, and simmer for five minutes:—set by till next day;—boil the syrup and cucumbers again, and put them in glasses for use.

LABOR- SAVING Stunts *for* Camp Cooks

By MAURICE H. DECKER

Popular Science Monthly, August 1936

WHEN several men go camping together, the fellow elected as cook has the least fun of all. And the most work! I know because I've been that one many a time. At first I thought it was an honor, but that soon passed. I got tired out stooping over a smoky fire while the rest swam, fished, hiked, or just loafed. So I began to work out short cuts that would let me do my work more quickly. Now I don't mind being cook for I manage to have about as much time for fun as the rest. Here is how I work it.

Take fish first. Most camping trips are near water, which means fish meals in plenty. Cooking them can be either a tedious, painstaking task or an easy one. It's all in the know-how. First, the smart cook



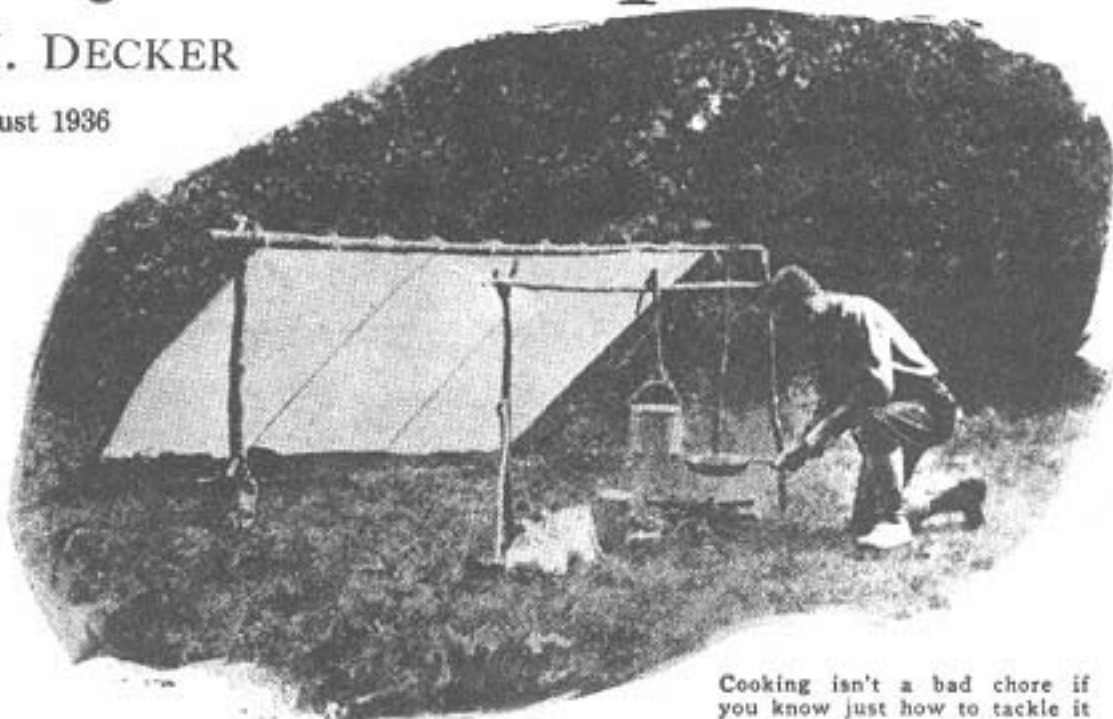
With this arrangement a loaf of bread can be baked clear through over the camp fire

makes each angler clean his own catch. Then he cooks it some way that takes a minimum of attention. What I call the Seminole fish dinner is a good one.

You need a pot with a tight-fitting cover. Dig a hole in the ground 10 in. deeper and 10 in. wider than the pot. Build a fire in the hole and roll a dozen fair-sized stones on top of the wood to heat. Keep the fire burning one hour.

To serve four, lay four slices of bacon on the bottom of the pot. Put the meaty sections of fresh-cleaned fish on these, allowing $\frac{3}{4}$ lb. fish per man. On top lay an onion, carrot, and potato for each camper. Pour over all a No. 2 can of tomatoes and half a cup of water. Season with salt, pepper, and four tablespoonfuls vinegar. (Lemon juice is better if you have it.)

Dig out the hot stones. Set the pot on



Cooking isn't a bad chore if you know just how to tackle it

top of the ashes in the hole and pack stones about its sides, putting a thin layer of ashes between pot and stones to prevent the food from scorching. Cover the lid first with ashes, then with plenty of earth or sods to hold in the heat. Go away and forget it for about two hours. When you come back, dig out the grub and if you've ever tasted anything better, write me what it was for I want some myself.

There's a lot of bunk floating about on how to make bread in camp. Let me tell you how to bake bread without an oven and in a loaf that tastes like bread and not like flapjacks or burned toast.

Mix your dough from this recipe, all measurements being level:

3 cups flour
5 teaspoonfuls baking powder
4 tablespoonfuls cold grease
2 teaspoonfuls salt
Cold water to make a medium soft dough

Cut the top and bottom off a small can, such as a condensed milk tin, and grease it outside. Shape the loaf about this, standing the can erect in the center. Lay it in a greased pot with cover. Fill a larger pot or pail half full of small stones and set the covered pot down in them. Support the whole on three rocks over your fire. The can in the center of the loaf makes it bake deliciously clear through, not charred outside and doughy inside as so many camp loaves are. Have a good fire and test the bread with a sliver of wood after fifteen minutes. When the sliver comes out clean, you can be assured that the loaf is well done.

Maybe some wise guy suggests baked potatoes. Don't bat an eye. Say "sure" even if there isn't an oven in fifty miles. You can bake 'em, cowboy—bake any vegetable perfectly and with little work.

I know what you're thinking, but you're wrong. I don't plaster them with clay or mud. Such a mess and so much work! Just scrub the spuds and wrap each in a sheet of oiled paper. (Wise camp cooks pack a wad of this for various purposes.) Plain paper—not newsprint—will do in a pinch.

Get an old pail or can and fill it two thirds full of sand. Bury the wrapped potatoes in the sand and set the pail over the fire. If rocks are scarce, use three empty tin cans full of dirt for your triangular-spaced supports. Build up a good fire and go away and play. Two hours later wander back that way, kick over the pail and pick out the spuds.

You needn't stop with potatoes, either.

You can use this

stunt on yams, tomatoes, apples, and eggs, to say nothing of cased sausages, pork chops, and fish. Meat should be seasoned and wrapped in two separate layers of paper. Split the fish and put a slice of bacon in the cut before wrapping.

Now suppose they want stew or bean soup for dinner. Good stuff all right, but it usually takes a lot of fire feeding and watching. Here's how you can beat that racket. Build your fire down in a hole dug 18 in. deep. Sling the kettle over the hole and after your fire is going good, slant thick sticks of fuel on end all around the sides of the hole, as shown in one of the drawings. Use more green wood than dry so the sticks feed down slowly on the coals as needed. This fire will burn for at least three hours. Be sure before you leave that the food in the pot is well covered with water.

Here's a stunt for green-corn time that started back in the bushwhacking days of the Civil War, but it tastes just as good today as then. Twist an ear out of its cover of husks and insert a cleaned, seasoned fish. Tie up the ends of the husks and bury in the hot ashes of your fire. In forty minutes you'll have a steam-cooked flaky dish that makes you wish stomachs were twice as big.

If you camp for a week in one place, by all means make a bean hole. Then you can serve beans like nobody's mother ever did unless she had a bean hole too. Dig the bean hole in dry, solid earth. Make it just a little larger than your pot. Build a fire in the hole. Now here's the secret of this bean-hole business: You must keep that preheating fire going for at least four hours! You've got to heat the ground surrounding the hole and heat it well.

For four men use 2 lb. or 5 cups of beans. Soak them over night, parboil with a little soda, and drain. Add:

- 1 large bottle catsup
- 1 lb. bacon
- 1 onion cut fine
- 1/4 lb. brown sugar
- 1 teaspoonful salt
- 1 teaspoonful mustard
- Enough water to stand 1 1/2 in. above the beans

If the potlid doesn't fit tight or if the beans were not well soaked, double the amount of



For stews or soups requiring long cooking, the fire is made in a hole so that sticks will feed down slowly



Potatoes are easily baked in a pail of sand

water. Empty the hole, set in the pot, and pack ashes around and over it. Cover with earth, heaping it 2 ft. high over the top of the hole. A piece of canvas spread directly over the potlid makes it easier to uncover.

Leave the beans in that hole for twelve or fourteen hours—longer won't hurt. Camp cooks often pack the hole in the evening so the beans are ready for the following noon.



Camper's Night Torch From Pop Bottle

A CAMPER'S torch or emergency outdoor light can quickly be improvised from a pop bottle and a stick. Cut a slit in the top of a metal bottle cap that will fit tightly back on the bottle, and insert a long wick that will reach the bottom of the bottle. A substitute wick can be made by folding cotton cloth. Lash bottle to a stick and fill it with kerosene. When the wick is saturated, light your torch. It gives a large, yellow light that will burn in a high wind.

Minnows in Glass Jug Attract Fish to Hooks

NO SITTING around waiting for "bites" when you use

this fishing lure. It's a "sure fire" drawing card for still fishing. To make it, all you need is a two-quart or gallon-size glass jug. From a piece of screen, cut a circle large enough to fit over the top of the jug. Then remove the cap from the jug and cut out the top of it so that just a slight ridge remains around the top. Fill the jug with lake water and put a few live minnows in it. Place the screen over the mouth of the jug and screw the cap over it. Tie a string to the jug and drop it over board. Fish are attracted to the minnows.—"Bob" Poulson.



Glass Marbles Break Lumps in Salt Shaker

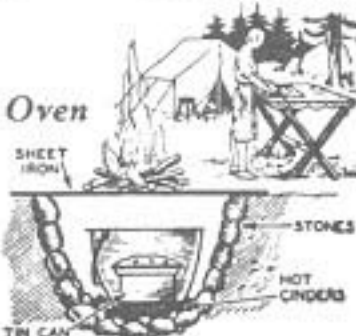
IN DAMP weather, salt will cake up over the holes in the top of the shaker, and will cake up into hard lumps inside. If a few common glass or porcelain marbles are placed with the salt inside the shaker they will stir up the salt continually as the shaker is used, and keep it running freely even in the dampest of weather. Different sizes and numbers of marbles can be used, according to the size of the shakers.

—A. H. Waychoff.



Here's How to Bake Pies and Meat in Ground Oven

FRESH baked foods certainly are a treat when camping out. A cook oven that will bake your pies, breads and meat to a rich brown is made by digging a hole in the ground about 2 feet deep and 2 feet wide. Line the hole with rocks and cover with a piece of sheet iron. Light a fire on the iron and the heat from the cinders and the fire will bake your food.—John Warren.



Pickled Eggs.—If the following pickle were generally known, it would be more generally used. It is an excellent pickle to be eaten with cold meat, &c. The eggs should be boiled hard (say ten minutes), and then divested of their shells; when quite cold put them in jars, and pour over them vinegar (sufficient to quite cover them), in which has been previously boiled the usual spices for pickling; tie the jars down tight with bladder, and keep them till they begin to change colour.

Preserving Potatoes.

The preservation of potatoes by dipping them in boiling water is a valuable and useful discovery. Large quantities may be cured at once, by putting them into a basket as large as the vessel containing the boiling water will admit, and then just dipping them a minute or two, at the utmost. The germ, which is so near the skin, is thus destroyed without injury to the potato. In this way several tons might be cured in a few hours. They should be then dried in a warm oven, and laid up in sacks, secure from the frost, in a dry place.

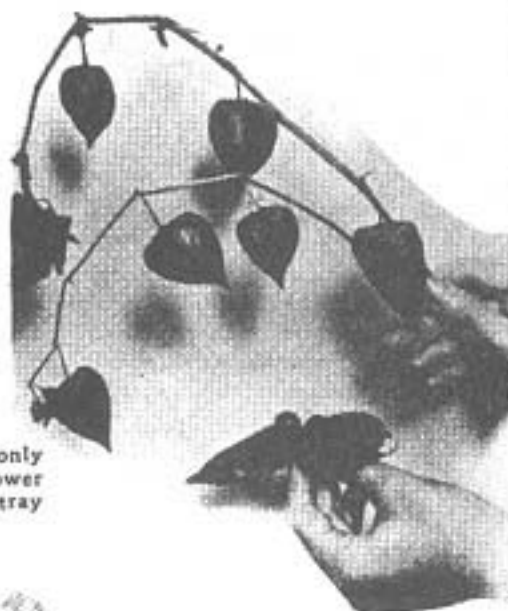
Butterflies and Moths, however pretty, are the worst enemies one can have in a garden; a single insect of this kind may deposit eggs enough to overrun a tree with caterpillars, therefore they should be destroyed at any cost of trouble.

GROWING Garden Seeds

Popular Science 1933



When the petals of the aster have all withered, leaving only the dried seed pod, the seeds are gathered. The grower crushes pod with his hands and then drops it in the tray



Seeds of the coxcomb are found beneath the flower and drop off when the plant is shaken. In the case of the dahlia, at top, the seeds are in the center of the flower. At left, the Japanese Lantern must be torn apart in order to get access to its seeds



Now Giant Industry



WHEN you consult the spring catalogs and lay in a supply of seeds for your garden, do you ever wonder how they got in the packets? On these pages the POPULAR SCIENCE MONTHLY photographer takes you behind the scenes in the seedman's nursery, where experts labor to make sure the seeds you buy will yield fine flowers or vegetables. Collected in trays, the ripe seeds are washed in screen-bottomed containers. Spraying or fumigation destroys parasites that attack the larger types. Sorting, vacuum-cleaning, and weighing machines handle seeds sold in bulk. To fill flower seed packets, like those above, girls use oddly-notched wooden spoons. Large growers raise many of their own seeds, purchasing the balance from individual raisers. The search for the best varieties extends to far corners of the globe.



To get the seeds of a squash, it is left on the ground until it withers. Then it is opened and the seeds collected. At top, taking out seeds through a hole in a pumpkin. At right, watermelons are split and dropped in keg where they ferment so seeds sink





In order to protect seeds from parasites, formaldehyde and other chemicals are sprayed on them as is shown in photo



Corn is left to dry still attached to the husk and stalk. When thoroughly dry it is shelled, tested, and selected kernels only are retained for seed

Seeds stored in bags are apt to become infested with bugs and so occasionally they are placed in a vault and fumigated with carbon disulphide fumes. Vapor is released by container here being filled with liquid



Seeds are fanned free of hulls and chaff and then they are flushed with water, as is being demonstrated below by Joseph W. Bedman, well known seed grower. Cleaning seeds in this way is the first step in their treatment after being gathered



This elaborate machine at the Peter Henderson seed plant discards the shriveled and worthless seeds. Photo shows peas pouring into the trough, whence they pass into the triangle-shaped sections where they are vigorously shaken, forcing the light seeds out at the back



This vacuum cleaning machine sucks the heavy dirt into the bag at left, chaff into center bag, and delivers seeds into basket



Last step of all is filling the seed packages as you buy them at the store. Here flower seeds are being placed in paper containers. Notched wooden spoons, holding definite number of seeds, are used

Chicago Tribune
Oct. 13, 1977

For many, goat milk is heaven-sent

By Carol Rasmussen

Food Guide director

CHICAGO, THE TOWN of broad shoulders, big business, and the new downtown, has a big business dairy that still remembers its small, family-owned origins and carries four little known and esoteric milks.

The dairy is Brook Hill, and it sells through chains or other such outlets milks labeled enzylac, low sodium, and goat.

The fourth milk, acidophilus, which is made from a special culture in a process akin to making buttermilk, was once known and loved by the first wave of natural food freaks of the 1930s and '40s. This slightly tart milk could be heading towards a new, alltime peak of popularity (which wouldn't be too hard since it's entirely likely that 74 out of 79 people back then never heard of it).

Our money is on acidophilus, what with the frenzy over yogurt and all things tart and clotted, especially since we're told that acidophilus is mild and tends towards sweetness rather than tanginess. But, in our heart, we favor the goat.

NUTRITIONALLY, THE goat makes good copy. Her milk is given to crying babies who are allergic to cow's milk, because the milk of a goat has a softer curd that is easier to digest. Doctors often recommend goat's milk for convalescents, stomach ulcer sufferers, and those who are sensitive to cow's milk.

Goat's milk is also good for conversation: reactions could range from mild acceptance to outright rebuke. It has its own unique flavor which can be mild but noticeable when the product is fresh, or it can develop into a full blown flavor which is often likened to the essence of barnyard.

But the real reason why goat's milk should make it is because goats sound so lovable. And because it took a lot of creative genius to get goats to produce milk all year 'round.

A goat farmer not too far from Chicago figured out how to outwit Mother Nature, and for that he undoubtedly earned the gratitude of legions of mothers with colicky babies. To them, Harvey Considine of Portage, Wis., could walk on water.

THE PROBLEM WAS an age-old one:



The goat produces the milk that more than 60 per cent of the world's population drinks.

goats don't give milk after their kids are old enough to fend for themselves, which meant that from December to February mama goats are nearly dry.

So Considine began experimenting to see if he could change the goat's sex cycle. It was a labor of love, if you pardon the pun, for Considine is enamored of the animal.

Goats are "very intelligent animals," he boasted. "I once sold a goat to a 4-H kid and she house broke it. She lived in a \$50,000 Colonial house and it never made a mess."

Normally, goats come in heat in the fall, give birth in the spring, and nurse their young through the fall. Mother Nature set this timetable by making goats sensitive to light so that the female would be ready to breed 10 weeks after the longest day of the year.

CONSIDINE'S TASK was to change that pattern and get some goats to freshen in the fall and produce milk all winter.

It was a formidable task, given to eons of tradition.

He remembered that the United States Department of Agriculture in Beltsville, Md. had tinkered with the sheep-breeding cycle to produce two sets of lambs per year, and sheep, too, are photosensitive. In that case, the USDA superseded nature by blacking out the sheep barn for a certain time every day.

"So I put black tape on the windows, but goats are very curious creatures. They chewed the tape off the windows and monkeyed around with the door latches and got out."

Considine finally fooled the goats by lighting the barn 20 hours a day during the winter, so the goats thought mid-March was mid-June and the rest was easy.

THESE GOATS are all registered purebreds. He, his son, and one other man are the sole suppliers of goat's milk to Chicago, Considine said.

For those readers who want to see if all this fuss is worthwhile, goat's milk is available at Uncle Charlie's fast food restaurant at Foster and Central, next to Brook Hill Dairy (which doesn't sell to the public). Jewel and Dominick's will special order goat and other speciality milks through a store manager. Acidophilus is available at Dominick's.

Goat's milk is a premium priced item. Jewel asks \$1.44 a quart and Uncle Charlie, \$1.59, in comparison to the good old "American" cow's milk now selling for the un-American price of 51 cents a quart.

But the high price exists only because we are out of step with the rest of the world. Sixty per cent of the world's people craves goat's milk, Considine noted, which just might go to prove that people drink what's available and grow to like it.

Technology Plowing Under Bigger Crop Yields of Future

THE MILWAUKEE JOURNAL Sunday, February 5, 1978

By Paul Shinoff

Washington Post Service

America's "green revolution" may be over.

The intense 30 year industrialization of the nation's farmlands, during which crop yields more than doubled through the introduction of complex harvesting machinery, petrochemicals and genetically engineered crops, appears to be at an end.

"We are bumping against the ceiling of applied technology," says John Timmons, professor of natural resources at Iowa State University. "Unless we are able to develop new technologies, our productivity is not going to go up."

A survey of major crop yields in the last decade shows that, while production has continued to rise as unused farmland is brought back into production, the yields per acre of major grains have dipped and swung in patterns unmatched since the Dust Bowl years of the mid-1930s. Agriculture Department statistics for 1977 show corn and wheat below the yields attained in 1972.

But what is of increasing concern to many agronomists

and agricultural economists is that recently developed farm technology may have masked, or even contributed to, serious problems, particularly the decline in the quality of the nation's soil.

The most serious problem, they believe, is increasing erosion, particularly in the Midwest corn belt.

Scientists contend that the heavy use of fertilizers has allowed crop yields to stay at relatively high levels. They warn, however, that this could be a short term effect.

Unless topsoil erosion patterns are corrected, they say, yields will drop considerably, and production costs will increase dramatically.

Other major problems include increased sedimentation as topsoil and fertilizers run off into streams and reservoirs; depletion of irreplaceable supplies of ground water in the Missouri Basin and sections of Texas; compaction of soil through use of heavy machinery, and use of high quality farmland for urban development.

In a report to Congress last February the General Accounting Office warned that because of excessive erosion, farms in the Great Plains, corn belt and Pacific North-

west were losing topsoil at a rate that threatened crop productivity.

Topsoil is crucial to crop production because it contains most of the organic matter and a major share of the nutrients required by plants. As a general measure, scientists say losses of five tons per acre are acceptable in areas of good quality soil. But in a random study of 283



farms the GAO found that 83% had losses higher than that.

The GAO quoted from a report by the Council for Agricultural Science and Technology (CAST) that indicated that corn belt farmers were less effective in controlling erosion than they were 15 years ago. The report

found that the US was losing 4 billion tons of topsoil a year in 1972, compared to 3 billion tons in 1934.

Much of the blame for increasing Midwest erosion has been laid on farmers who rushed to get more land into production to take advantage of rising grain prices after the 1972 US-Russia wheat deal.

Increased use of fertilizers has allowed a shift away from soil conserving crop rotation and has allowed farmers to make more intense use of the land through single cropping or rotating major cash crops.

Agricultural scientists are increasingly concerned that even the most advanced techniques can have potentially catastrophic side effects.

Genetic engineering, the ability to create single strains of fast growing, reliable food crops, is one of the cornerstones of modern agriculture. But such high yield crops also can have little resistance to unforeseen diseases and are often susceptible to pest infestation.

Even the harvesting machines may have reached their zenith.

"Machines are at a very high stage right now," says Roger Garrett, chairman of the Agricultural Engineering School at the University of California at Davis. "The efficiencies are pretty high; we capture up to 95% of the grain already. It's hard to imagine being able to improve upon that."

TRAPPING ANIMALS FOR FOOD

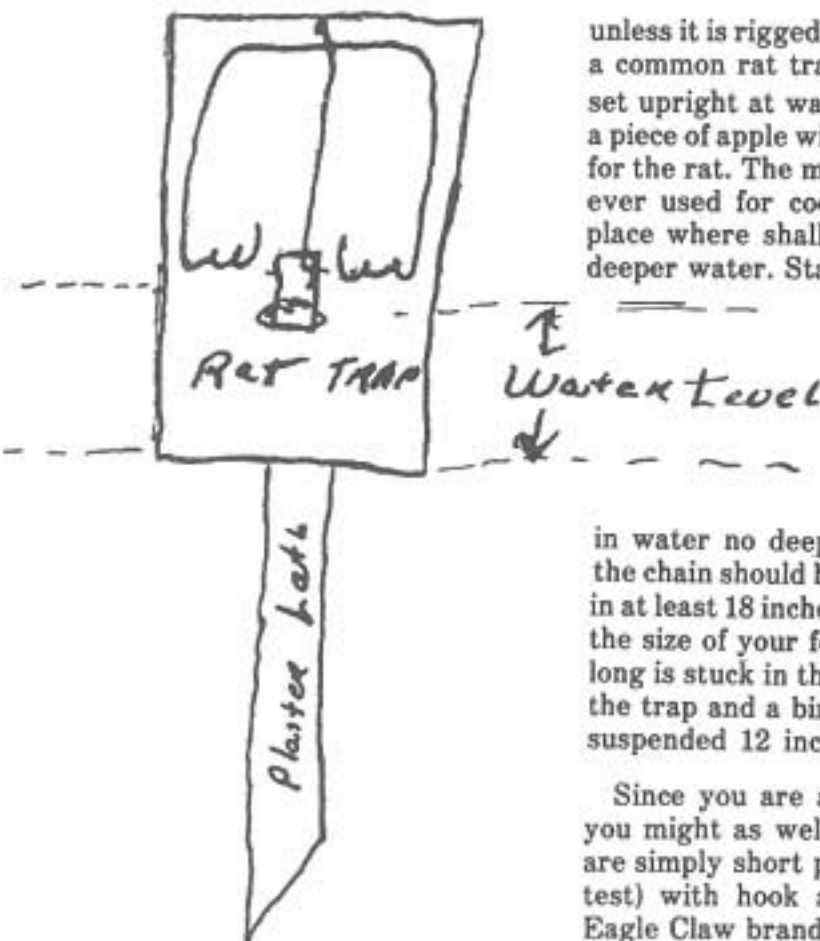
by Gordon Couger

During the period between the breakdown of today's society and the establishment of whatever comes next, we will have to furnish our own food, shelter and all essentials of life. During this time fresh meat will be a great morale booster, if not a necessity due to theft, spoilage or inadequate stores.

While most people will find hunting or fishing for meat to be more enjoyable than trapping and troutlining, the trap and the bank line will put much more meat on the

table for the time expended than anything else except livestock farming. The fact that livestock will attract those who would rather steal yours than provide their own will make less obvious methods safer and trapping and troutlining are most inconspicuous methods. If necessary, traps and lines can be run at night for the least chance of observation. A red lens over your light will greatly reduce your chances of being observed by man and is completely unnoticed by wildlife.

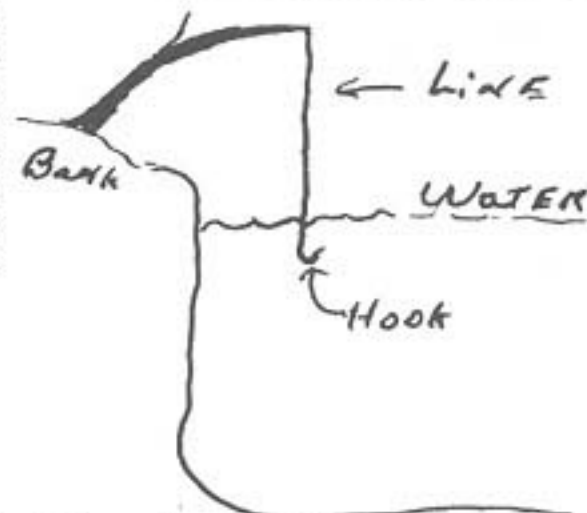
Many good books are available on trapping. The A.E. Harding Co., 2878 E. Main St., Columbus, Ohio 43290 has several inexpensive books on trapping and related subjects. Drowning or killer sets should be used not only for humane reasons but also to prevent struggling animals from calling attention to your traps. For dry land sets size 220 Conibear traps, deadfalls or snares should be used. Tompkins or Herters locking snares are very good in that they require no lifting pole or associated triggers. Most books on trapping deal with catching furbearers. Of the furbearers the possum, muskrat and raccoon are the best eating; however when you are hungry meat is meat.



unless it is rigged to drown him. However, a common rat trap nailed to a stake and set upright at waterlevel and baited with a piece of apple will prove deadly medicine for the rat. The most successful set I have ever used for coon is as follows: pick a place where shallows go very quickly to deeper water. Stake the trap so that it is

in water no deeper than six inches. But the chain should be fastened to the bottom in at least 18 inches of water. A limb about the size of your forefinger and three feet long is stuck in the bottom 12 inches from the trap and a bird wing or rabbit skin is suspended 12 inches above the water.

Since you are already near the water you might as well go fishing. Bank lines are simply short pieces of heavy line (30# test) with hook attached (size 2 to 2/0 Eagle Claw brand being the best) tied to branches overhanging the water. If a branch is not where you want it, cut one off about four feet long and about the size of your thumb and stick it firmly in the bank where you want it. The best place to set out bank lines are near deep water and



at the upstream end of holes. The baits should usually be set near the surface to prevent fish from tangling the line around some obstruction and thereby gaining their freedom. If you don't catch fish try deeper. Natural baits usually are best for this type of fishing. Chicken entrails, worms, minnows, small perch, grasshoppers, etc., make excellent bait.

If at all possible you should gain some experience trapping before relying on it for your groceries. The best way is to trap with someone who is good at it; failing that read a good book on trapping and try your hand.

The trap line can be very enjoyable and much more profitable at today's prices for fur.

The possum is the easiest animal to catch on the face of this earth. All that is necessary is a high smelling bait and an unconcealed Conibear trap. The muskrat is hard to hold in a conventional trap

TWO FOOD ARTICLES

by Susan Kramer

MALT "COFFEE"

What's going to happen when the food processing plants shut down because of some disaster? People will have to "process" their own food. How many housewives grind their own wheat berries for breads or even make their own bread from all ready ground flour? So what if you have hundreds of pounds of grains under dry ice in your bomb shelter. Does any of your family know how to prepare these foods so that they can be eaten and digested? Do you depend on coffee or tea imported from a foreign country to start your morning? Well, if you find yourself in a predicament where coffee and tea are not available you might think of malt "coffee" as your hot drink of the day. We ran out of coffee and tea one day and live too far from the store to get more immediately. We found malt coffee a satisfactory substitution.

Malt coffee can be made from just about any grain. I use wheat berries because they sprout so fast. First soak the grain overnight. The next morning you should place the soaked seeds in an environment conducive to sprouting. There are various

methods of sprouting seeds. Try them all to see what method suits you the best. Kurt has a seven day sprout set up in the OLD TIME HOME FOOD PROCESSING book. Another popular method is putting the seeds in canning jars with a screen lid. Whatever method you use, rinse the sprouts two or three times a day. When the sprouts are the length of the seeds in the case of wheat berries roast them in a slow oven (about two hundred degrees) until dry. Run the toasty dry sprouts through a coarse grinder or mash with a mortar and pestle. This is malt. Use it as you would any other ordinary coffee or tea. Delicious roasted flavor!

VITAMIN C FOODS OF SURVIVAL

A lot of the foods that automatically come to the middle class American minds in connection with vitamin C are going to be just "hard to come by" once the trucking lines run out of gas and thus the supermarket is closed. Fresh citrus fruit such as grapefruits, oranges, lemons and limes will not be available in most parts of the country. Melons, cantaloupes, brussel

sprouts, broccoli, and fresh tomatoes will no longer be so readily available to those who do not produce them at home if there is no gasoline for their transportation.

Most of the year fresh fruits and vegetables are not available to my family now because we live where there is no road and our garden is not well developed yet. It is impractical to pack many fresh foods on your back or an animal because of the water weight. We depend on rosehips, red pepper (cayenne), garlic, sprouts, mustard greens, turnip greens, kale, beet greens, parsley, dried fruit, and wild greens such as miners lettuce, dandelions, pigweed and plantain.

Rosehips are the fruit of the rose bush, left after the flower has disappeared. In many countryside wild rose hips are eaten only by the animals. The vitamin C content in citrus fruits is much less than in rose hips. One orange weighing one hundred grams has 50 milligrams of vitamin C; whereas, on hundred grams of rose hips has 500 to 600 milligrams of this precious vitamin that cannot be stored in our bodies according to the HEALTH FINDER. During World War II, England gathered rose hips and made national rose hip syrup due to the lack of fresh fruits. Why wait for an emergency to eat this delicious food? Besides being high in vitamin C, rose hips

contain vitamins A, E, K, B1, B2, and P.

Red peppers are not actually vegetables, but fit into the category of berries. The fresher the pepper the more vitamin C it contains, however, even dried hot pepper is high in this important vitamin. There is always dried powdered red pepper on our table and we use it as many people would use black pepper. Many natural vitamin C tablets are made from red peppers or rosehips. You can preserve red hot peppers by drying or pickling. Our favorite type of red pepper is known as capsicum cayenne.

Sprouts are an excellent source of vitamin C as well as protein, fat, minerals and other vitamins. A dried seed contains little or no vitamin C. As you sprout seeds you increase their vitamin C content. According to Rodale's HEALTH FINDER, one hundred grams of dry peas increase from a vitamin C content of zero to 86

milligrams of vitamin C after 98 hours of germination. See Kurt's seven day sprout set up in his OLD TIME FOOD PROCESSING FOR FUN AND PROFIT for one idea on how to raise a steady sprout supply for your family.

Garlic also contains vitamin C along with its antibiotic powers. Since garlic also has a lower water content than most fresh foods, it keeps well and is easier to transport. It is also very hardy and will grow almost anywhere. I always separate my bulbs into cloves so that if one clove begins to rot it is not pressed smack up against another clove causing it to rot.

Greens are the salvation of the poor dirt farmer and I do mean poor dirt literally. If you wish to produce your own vitamin C and feel most vegetables and fruits would not do so well in your poor soil then plant those hardy greens. Mustard greens, turnip greens, parsley, swiss chard, and

kale all grow easily and will not be hurt by a light frost. In fact many of these greens make it all year in my northern California climate. Greens are excellent vitamin C sources.

Many wild plants are high in vitamin C. Check with your local people on the edible wild plants in your area. A synthetic vitamin C tablet is not as healthy as eating those foods which naturally contain vitamin C. This is because many of the things found in the food that the vitamin C needs to do its work in your body are not found in the synthetic vitamin C tablets.

Scurvy is a disease characterized by swollen and bleeding gums, livid spots on the skin, and prostration due to a lack of vitamin C in the daily diet. It used to be common among the sailors when they had little to eat except bread and salt meat. If for some reason, the supermarket is closed indefinitely, will you get your vitamin C? □

Herbs, Continued from page 1074

small flowers are used, I do not wash but try to gather those at the top of the plant or where they are clean. It would be almost impossible to wash and dry such small parts of a plant.

Roots of plants and trees are dug and washed well without scrubbing, dried and laid on horizontal screens to dry. As a rule the roots of annuals should be dug just before the flowering time; those of biennials and perennials are dug in late fall or early spring.

In preparing the herbs for use, the usual amount for tea is one teaspoonful of the herbs or seeds to a cup of boiling water—cover it and let it steep five to ten minutes. Ben Charles Harris says in "The Compleat Herbal", that such herbs as poke, rue, senna, and other laxative-purgatives, arbor vita, elder flowers, tansy, nightshade, pepper, ginger and mustard should not be taken in infusions (steeped). However, Donal Law in "Herbal Teas for Health and Pleasure" recommends ginger tea as warming and strengthening; used for colds, sore throats, nausea and as a mild stimulant but he recommends only one teaspoonful to 5 or 6 cups of boiling water.

The usual amount of barks and roots is a tablespoonful boiled (decocted) in a quart of hot water for a half-hour or down to half the quantity (1 pint). Use a stainless steel, enamel, porcelain or pyrex-glass (but not aluminum) utensil. Keep the lid on at all times. For internal use dilute with water. The dilution and the amount to be taken varies with the herb and since space does not permit me to give you all this information you may find it in "The Compleat Herbal" by Ben Charles Harris, published by Larchmont Books, New York.

A poultice of herbs is made by placing

them in a suitable cloth and soaking it in hot water two or three minutes. Apply as a poultice, over which is placed a hot water bottle.

An ointment is made by placing the herb or herbs in hot Crisco and squeezing it through a cloth.

An oil is made by placing one part of the herb in one part of olive or safflower oil. Let stand two weeks.

Some of the herbs suggested for use in making an astringent are aloe vera, basil, sweet bay, chamomile, garlic, lemon balm, mints, pennyroyal, rosemary and thyme. To make an astringent add herbs to rubbing alcohol. Use only externally.

Fresh or dried herbs may be added to fruit juice to make an herbal drink. Fresh-bruised or powdered ones are better for this.

To make a syrup simmer two tablespoonsful of the herb in a quart of hot water down to half the quantity (1 pint). Add one cup of honey to a pint of this liquid and simmer twenty to thirty minutes.

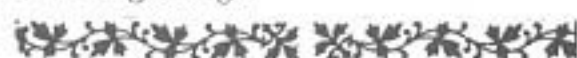
In the history of herbs we find two kinds of herbalists or medicine men; those who employed incantations, superstitions and magic and those who knew the herbs and what conditions they could cure. The former have been instrumental in giving herbs the reputation of being tales and superstitions. The latter may have used rituals and incantations, which may have had some psychological value, but they also knew and used herbs which were effective for certain illnesses. An example of these are our American Indians who taught the white man the use of our native herbs.

A very large number of our medicines have come from the plant world and many still do. Modern drug companies buy from free-lance wildcrafters who search for plants, roots and barks from which

medicines are made. One could not get rich at it but some of them make enough to make it a worth-while project.

Herbs are fascinating and one may well get hooked on collecting them to the extent that he cannot rest until he can identify a strange plant and discover its uses. I hope I have given you an incentive to start and enough information to start on. Happy hunting and happy drinking! □

1642. To Preserve Eggs.—It has been long known to housewives, that the great secret of preserving eggs fresh is to place the small end downwards, and keep it in that position—other requisites not being neglected, such as to have the eggs perfectly fresh when deposited for keeping, not allowing them to become wet, keeping them cool in warm weather, and avoiding freezing in winter. Take an inch board of convenient size, say a foot wide, and two and a half feet long, and bore it full of holes, each about an inch and a half in diameter; a board of this size may have five dozen holes bored in it, for as many eggs. Then nail strips of thin board two inches wide round the edges to serve as a ledge. Boards such as this may now be made to constitute the shelves of a cupboard in a cool cellar. The only precaution necessary is to place the eggs as fast as they are laid in these holes, with the small end downwards, and they will keep for months perfectly fresh. The great advantage of this plan is the perfect ease with which the fresh eggs are packed away, and again obtained when wanted. A carpenter would make such a board for a trifling charge.



PLANNING YOUR SURVIVAL ORCHARD

by George W. Preuss

Your food supply is too precious to trust to others. In contrast to poorer nations where 50-70% of the individual's income is spent on food, Americans enjoy relative food bargains despite inflation. Wheat, corn, and other basics often sell for under \$10 per bushel on the commodity exchanges.

The era of cheap energy and abundant food is ending. It takes energy to plow fields, sow seeds, produce fertilizer, make pesticides, harvest crops, transport food, process it, and ship it to stores. A truck strike, oil embargo, hyperinflation, wartime rationing, or protracted winter storm could trigger a consumer panic. The shelves would be emptied.

Next time you're shopping, look at the endless displays of packaged, devitalized, processed, high calorie, low value foods. Most Americans underestimate the importance of enzyme rich foods for maintaining good health. For example, fresh cherries lessen the discomfort of gout. (Charles Gerras, Ed., *ENCYCLOPEDIA OF COMMON DISEASES*, Rodale Press, Inc., 1976, pp. 107-112)

The Hunzas have a lower incidence of degenerative diseases like cancer and heart conditions. They drink pure water, and consume large amounts of fresh fruit. From the apricot kernels they get Vitamin B-15 (pangamic acid) and laetrile.

Don't let today's abundance of food deceive you. Self-sufficiency is your goal. \$200 buys 1 Krugerrand, or 35 ounces of silver, or a fine selection of fruit and nut trees that'll steadily appreciate in value during the coming depression. For example, despite inflation, in real terms, black walnut trees appreciate at 5% annually. Each black walnut will, in 30 years, be worth over \$1,000 in today's buying power. (Why rely on the bankrupt Social Security System for all your income?) During wars, famines and upheavals, fresh fruit is essential to your physical-financial survival. You could start your own business and have a valuable commodity for barter.

It takes several years before trees start bearing. If you want apples in 1984 you better start digging now. If we ever have a police state, food will be a controlled commodity. Why waste your ration cards on items that you can grow yourself?

As inflation accelerates, the hysteria will affect the nurseries. Today a bushel of apples costs more than an apple tree. Don't wait until your money is worthless, the post office bankrupt and the nursery

empty of healthy trees and seeds. With every postal increase, the nursery cuts the size and format of its catalogs. Save old catalogs which give detailed planting instructions.

Trees are a permanent installation. Careful planning is essential. Don't be discouraged if you own a city-size lot. You'll be rewarded with an abundant diversity of fruits.

Draw an accurate scaled diagram of your property. Don't plant trees near water-pipes, sewers, gas-lines, or too close to your home. You don't want rotten fruit, ants, squirrels and dead branches falling onto your roof. Don't dig near buried telephone cables. If you must plant a tree under an overhead line (inadvisable) select a bush or dwarf tree. A full-sized tree may require extensive pruning.

Think about the height and width of every tree at maturity. Don't feel dismayed when you look at the yard long, pencil thick saplings. They'll get huge. Don't crowd them. Anticipate shading conflicts. In 10 years, your black walnut will "overshadow" your dwarf plum tree.

THE RULE OF TWO. Poor fruit yields are often a symptom of poor pollinization. You'll significantly improve yields if you plant pairs of similar variety fruit trees within 100 feet of each other. This encourages cross-pollinization. Or else buy a self-pollinating dwarf North-Star cherry. Bees can be an excellent investment. Properly packaged honey can be stored almost indefinitely.

THE LAW OF LARGE NUMBERS. Some trees don't bear. Others get the blight. Have a diversity of apple, peach, plum, apricot, pear, cherry, pecan, and walnut trees. To discourage birds from eating your fresh fruits plant a mulberry tree to feed them. To discourage animals put a wire barrier around your young cherry saplings. Plant new saplings to replace old trees. Stockpile seeds, peat, and sand. Familiarize yourself with the scarce, less popular, but hardy varieties. For barter you want Red Delicious; for applesauce McIntosh; Cortland for pies; and Northern Spy for cider. Your efforts may prevent the extinction of rare varieties. You'll want to freeze fruit for the winter. If your area has power failures buy fruit drying equipment.

Decades before the Irish potato famine, Malthus warned of the dangers of monoculture farming. But history is quickly forgotten. The Paddock Brothers and other modern-day Jeremiahs will be vin-

dictated. The Green Revolution won't rescue you. Blight resistant, low yield, hardy crops are replaced by blight-vulnerable, high-yield, petrochemical fertilizer dependent ones. If you understand plant genetics, you probably feel apprehensive about endless fields of genetically similar plants. The Russians could use biological warfare to attack our crops.

World weather conditions have worsened. During hot and cold weather, record volumes of energy are consumed. During power failures, food in refrigerators and freezers spoils. Longer winters mean shorter growing seasons with more flooding. Long summers mean droughts. Colder winters bring deeper frost lines and sub-zero temperatures. Frail, exotic trees will die. Avoid trees with shallow roots or delicate structures. For example, in the 1960's, the Texas fig was marginally hardy in the Midwest. Today it often freezes, despite protective measures.

I urge you to read:

Lowell Ponte's, *THE COOLING*

(Englewood Cliffs, N.J.: Prentice Hall, Inc. 1976.)

Mr. Ponte explains that in terms of precipitation and temperature it's the same as if you moved 2.5 degrees farther north. For example, if you live in Chicago (about 42° latitude) you'll have weather similar to 44.5° latitude. Florida has weather like Georgia and Buffalo like Canada.

HOW TO APPLY THIS KNOWLEDGE TO YOUR ORCHARD.

The U.S. Agriculture Dept., in cooperation with the American Horticultural Society, developed the "Zones of plant hardiness" chart. It was based on the average annual minimum temperatures for the years of 1899 through 1938, and was adjusted in 35 states to cover the years from 1931 to 1952. Unfortunately, if we continue having long cold winters with hot summers you must plant superhardy trees. For example, if you live in Zone 5 (Upper half of Kansas, Illinois, Ohio, and Penn.) you should assume that future weather conditions and growing seasons will probably resemble the colder Zone 4 which is 2.5° farther north. (Page 67, of the 1978, Henry Field's Spring Catalog has a full page description of plant hardiness zones. Write:

Henry Field's Seed and Nursery Co.,
Shenandoah, Iowa, 51602

It's wise to own a Manchurian Bush Apricot (*Prunus armeniaca Manchurica*) which survives from -60° F. to over 115° F and it resists droughts. It needs little space, blossoms beautifully in the spring and bears when the tree is young.

Write: Lakeland Nurseries, Hanover, Penna, 17331. See page 7 of their 1978 catalog.)

Another problem is blossom losses on

peach trees. Avoid the delicate Southern varieties. Lakeland Nurseries claim that their "Arctic Peach" can survive temperatures above -25° F. (Page 26 of their 1978 catalog.)

If space limitations are a problem, buy dwarf trees. Henry Field's sells a "5-in-1" apple tree which bears red delicious, yellow delicious, jonathan, grimes golden, and McIntosh apples all on the same tree. (Page 39 of their spring catalog.) In contrast to a large, one variety tree, you'd enjoy several varieties at different times during the fall. Your fruit wouldn't ripen all at the same time. Lakeland sells a "3-in-1" dwarf tree that bears Bartlett, moonglow, and Kieffer varieties on a specially grafted tree. (Page 13 of their 1978 catalog.)

To reduce air-conditioning costs, plant long lived shade trees on the south side of your home.

PRAYING MANTIS POWER

Commercial pesticides often indiscriminately kill destructive herbiferous pests and essential beneficial carnivorous friends like the praying mantis and ladybug. Once the beneficial insects are gone, you need ever larger doses of the insecticide to kill poison resistant pests. Spraying introduces dangerous chemicals into your food chain. Petroleum-based commercial sprays won't always be obtainable. Buy a half dozen praying mantis

egg kits instead. Place them around your garden. Hundreds of praying mantises will devour beetles, moths, and cutworms. They don't bite humans, nor do they harm ladybugs.

PLANTING TECHNIQUES

Examine the tree. Is it what you ordered? It should be planted immediately. Dig the hole deep enough and wide enough. Breaking up the soil helps establish roots. Shallow holes encourage weak horizontal roots. Then the tree competes with adjacent trees for minerals and moisture. Pecan trees require deep holes. Once the vertical root gets established, it'll grow impressively.

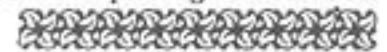
At the bottom of the hole, pour bone meal, peat moss, sand and other nutrients. This encourages downward root growth. Grapes and blackberries need iron, so bury a few rusty nails nearby. (Wild rabbits thrive in blackberry bushes.) If the ground is dry, it'll pull vital moisture from the roots, and dehydrate your tree. Fill the hole with water.

Improper planting techniques kill trees. Don't aim roots toward sewer lines, your home, or other trees. Don't bury the tree too deep, or leave exposed roots. Spread the roots out in different directions. Your tree must adapt to your soil, climate and weather. For the first couple months deep soak it every several days. You want your tree to establish deep roots that'll grow

toward the water table. Roots can "drown" so don't over-soak your tree with a daily "bath." Another mistake is light sprinkling. This encourages shallow roots that grow upward. Don't stomp on the soil around your tree. Excessive soil compression damages roots. The soil is alive with bacteria, air, earthworms, and other desirable life.

Be patient. I've seen trees thrive, wither and come back. My oriental pear cost \$.25. The upper branches were dead. Today it's 18 feet tall with white flowers. If your tree doesn't bud right away, don't dig it up! Late budding trees may protect your future food supply if unexpected spring frosts destroy early budding ones.

PRUNING. Your trees should have strong trunks. Trees that fork close to the ground are injured by mold, insects, and moisture. Mowing around low branches is difficult. Prune each variety at the proper time of the year. Gasoline based tars can kill trees. Use tree surgeon's tar. Y-shaped branch patterns are weaker than alternating branches that come out at right angles to the main trunk. Branches shouldn't rub against each other. Friction exposes inner sections to diseases and insects. Vital plant energy is wasted. Finally, all the leaves should get some sunlight each day. "Inner space" for air circulation and picking is essential.



SUNFLOWER POWER



By George W. Preuss

Faced with the prospect of a breakdown of our production-distribution systems, many people spend several dollars per pound for dehydrated protein, or purchase vitamin supplements. What can you do to increase your food supply if your garden space is limited?

Sunflowers can play a major role in your survival strategy. At least some of your food growing program won't be dependent on hybrid, genetically similar, blight vulnerable grains or crops. The Helianthus (sunflower) matures in about 90 days. Despite unpredictable weather, shorter growing seasons or if your plants take longer than expected to mature you still have a high probability of at least one harvest.

As a hedge against catastrophic growing conditions (droughts, or nuclear war, etc.) it's wise to have several vacuum packed cans of raw, shelled, unsalted sunflower seeds in your survival kit. Small containers, even if they cost a little more, are better than the institutional size cans which could get contaminated or the contents rancid. Raw-hulled seeds give you

the maximum nutritional value with the least effort. Toasting often destroys delicate, essential nutrients. Avoid salted sunflower seeds. These are a natural low sodium food. Your other foods will have excesses of salt in them so why strain your body with unneeded salt? Once the vacuum sealed can is opened, keep it refrigerated until the seeds are consumed. Otherwise the important unsaturated fatty acids will get rancid.

In planning your garden several important facts should be remembered. Sunflower seed packets should be rotated on a first-in, first-out basis from your seed library. Germination rates vary among companies, and even among different batches from the same company. With the passage of time, fewer seeds will germinate, but if you store them properly, and have enough, even after several years, some will grow. Care must be used to store them away from where rodents or birds can find them.

To start your seeds, empty egg containers filled with sand and potting soil work well. After the chance of frost is over and

before the growing season is over, is when they should be planted. The larger the plant, the worse the transplant shock. If you transplant 2 foot plants they may droop and even seem to wilt for a day or two. Water them and they will take.

One effective strategy is to plant your sunflowers slightly more than one lawn mower distance apart. Then you can keep the weeds trim and they'll have sufficient root space.

To produce high-quality sunflowers with high vitamin and mineral contents they should be cultivated in good soil. Before transplanting it's wise to break up the soil, remove rocks so the roots can reach out.

Sunflowers exhibit extreme heliotropic behavior. They actually turn toward the sun throughout the day. In useless places in my garden where other plants die from the summer sun, the sunflowers blossom. Like any living plant, if the soil becomes excessively dry, the leaves and flower will wither. In hot weather, keep their soil lightly moist.

If the flower wilts from the drought, or gets cut off or snaps from the sheer weight don't rip the plant out in frustration. The sunflower will generate one or more new flowers either at the top or

toward the top. Make sure it has enough water and sunlight.

Giving the long, almost mature sunflower adequate support is a major problem. The huge, heavy flower and the long thin plant are vulnerable to high winds, heavy rain, hail and gravity. Unsupported plants fall over, ripping out their roots. Young plants are transplanted below clotheslines, or gently guided by loose cloth strips that are tied to wooden poles. Whenever stakes are driven, great care must be used not to damage roots. Drive stakes and plan your supports before transplanting.

Sunflower seeds are more than a pleasant snack; they are a sensible alternative to the high-salt, high sugar junk-food trap that most non-survivors will fall

into when high quality food is unavailable. During any protracted crisis, nations ration meat and other protein products. By supplementing your meat, eggs, fish and chicken with sunflower seeds, you could help bring up your daily minimum gram protein needs to a nutritionally safe level. Ounce for ounce, sunflowers contain more protein than hamburger, and this easily digested plant protein is a rich source of vitamin D, E plus essential unsaturated fatty acids. In other high protein foods, like peanut butter, manufacturers nullify any dietary benefits by adding refined sugars, salt, and hydrogenating it to give it a longer shelf life. Other foods have protein, but they lack certain essential amino acids that the body requires.

Since the seed is a concentrated storage plant of future life, it represents concentrated nutrition. Most people know that it is rich in the B-complex vitamins. (B-1, B-2, B-6, niacin, para-amino benzoic acids, biotin, as well as choline, inositol, folic acid and pantothenic acid.) Don't overlook the important possibility that sunflower seeds have unproved or unrecognized dietary values like the F.D.A. disputed "vitamin B-15" or pangamic acid. (Pan means all, while gamate is seed.) This may be a detoxification agent (like Vitamin C or E) which attacks body poisons or slows down the aging-illness-breakdown-death cycle. Or possibly when seeds are eaten with high roughage foods this aids the elimination of wastes that would poison the body. □

SAVE THE FAMILY FARM

In the early 1970s Russia suffered disastrous crop failures. Their government blamed the weather and inefficient collective farmers. Bureaucratic bungling was an important factor.

The Russians then bought up all America's surplus grain. Fearing shortages here and hoping for more Russian crop losses, the U.S. government encouraged the American farmer to bring more land into production. Our farmers did as they were asked. Our banks gladly loaned them money for more land, seed, fertilizers, pesticides, herbicides and more and much larger farm machines and the fuel to run them.

For a while the farmers did well. Then the Russians figured that if Americans could get bogged down in a no-win war in Vietnam, they could do as well. So they invaded Afghanistan. President Jimmy Carter, reared as a farmer, nonetheless cut off grain sales to Russia on behalf of the Afghans.

The Russians simply turned to Canada, Australia and Argentina. Also, Russian bureaucrats eased up on their farmers and their own grain production rose.

This left American farmers with millions of acres devoted to grains no longer in short supply and actually a growing surplus, costing the U.S. taxpayer over \$9,000,000.00 a day to store. And the American farmer goes on growing grain without a market until the bank relieves him of his counterproductive farm.

John Redman Cox, writing in *The Emporium of Arts & Sciences*, 1812, proposed a crop which might be the solution to those farmers who have not yet gone bankrupt. Sunflowers are a temperate crop. They will grow well on marginal land without irrigation. After planting they need no cultivation and with modern agricultural methods should be double

the production of 1812.

Sunflower seeds, oil, seedcake, cordage, etc., would give the farmer a much higher profit than grain. This is especially true since they require no fertilizer, pesticides, herbicides or post-planting cultivation.

Observations on the Various Uses to which the Sunflower may be applied. By the EDITOR.

Philadelphia, October 3, 1812. JOHN REDMAN COXE.

THE advantageous employment of this plant does not appear to have been sufficiently appreciated. The object of this essay is to attract the attention of those who may have it in their power to pursue the enquiry to its full elucidation; and it is expected, that this may be readily accomplished by persons residing in the country, with little expense or trouble to themselves, and with real benefit to the community, if their experiments shall satisfactorily demonstrate the presumed merits of this very common and luxuriant product of the vegetable kingdom.

In a letter, published in the first volume of the *American Philosophical Transactions*, from Dr. Otto of Bethlehem to Dr. Bond, we have an account of the oil produced "from the seeds of the common large sunflower," by methods very similar to the extraction of linseed oil; one bushel of the seeds yielded about three quarts of oil; and he states that it was frequently used on salad, for which it answered very well. The committee, to whom the specimen sent was referred, report it to be thin, clear, and agreeable to the taste, and are of opinion, that it "will supply the place of olive oil for the above, and many other purposes; and may, therefore, be looked upon as a valuable discovery to America.

Immediately following this communication, is an essay by Dr. J. Morgan, "on the expressing of oil from sunflower seed," in which we are informed, that it is found from experiments, that a bushel of the seeds will yield, on expression, near a gallon of mild oil. And he gives the account, from a correspondent at Lancaster, of certain results upon this subject, from which we learn, that one hundred plants, set about three feet distant from each other, &c. "will produce one bushel of seed, without any other trouble than that of putting the seeds into the ground,

from which he thinks one gallon of oil may be made." "By an estimate made, it appears, that one acre of land will yield to the planter between forty and fifty bushels of seed, which will produce as many gallons of oil." The remainder of the essay is taken up with many valuable observations on the mode of expression, and on other points connected with the subject, which are unnecessary to be here transcribed, since the whole of the original communication will be advantageously read, by any one who finds an interest in the present essay.

Mr. John Saunders, of Gloucestershire, (England) has called the attention of the public, in *Dickson's Agricultural Magazine*, No. 6, to "the use of the seed of the great sunflower, (*Helianthus annuus*) as a food for swine, rabbits, poultry, &c." in which communication he reckons that an acre will produce from fifty to sixty sacks, (weight of sack not mentioned,) the profit of which, at the low rate of two shillings and sixpence per sack, is estimated at four pounds sterling per acre. He remarks likewise that the stems partake so much of the nature of wood, that, when perfectly dry, they may be burnt as fuel, an acre affording from three to nine waggon loads. He suggests also their use by wattling and other modes, to enclose sheep, and to guard them from the inclemencies of the weather; and that, where there are dry walls, with the aid of rafters and hurdles, they might be converted into an excellent covering for temporary sheds in the fields, and about the homesteads, for pigs and other animals. He recommends the leaves as an excellent green food for rabbits, or as serving for litter when dried. The plants, too, he affirms, will remain a long time after they are ripe, without shedding their seeds, through

neglect of gathering, and are not liable to be injured by rains, or destroyed by the attacks of birds. He mentions the cultivation of the plant in France for the sole purpose of extracting an oil; and he recommends sowing the seeds very early in the spring, if not in December, as the early sown plants always arrive at the greatest height, and produce the largest quantity of seeds. The whole paper is worthy of perusal.

The mode of culture is given in the same magazine, No. 7, by "Amicus," from Br. Willick, and Mawe and Abercrombie's *Gardener's Calendar*. This person states the use of the oil in *printing*; and of the *cake*, after expression of the oil, in feeding a pair of small oxen, who eat it greedily, and thrive well upon two pounds a day. He further states the oil to be as fine transparent sweet oil as ever was produced from almonds; and that eighty pounds weight of clean seed produced eight quarts of oil, part of which he used in lamps, and found it burn with great pureness and brilliancy.

In No. 9 of the above mentioned magazine, a writer conceives, that it may be successfully cultivated for the purpose of supplying clothiers with oil, instead of using the Florence oil imported from the Levant, and which is sold to them when it becomes rancid, for the purpose of softening their wool, when preparing for the loom.

We have another writer on the subject in the 27th No. a Mr. John Wright, who estimates the crop produced by him at not less than twenty quarters of seed to the acre; though he considers it a tedious crop to harvest, from its ripening at so many different periods: he nevertheless ap-

pears to think well of it upon the whole.

I have thus collected a mass of facts, which altogether, I think, render this plant worthy the attention of the farmer, and afford adequate encouragement to a fair trial of its real importance, in affording a most important article to the painter, printer, clothier, and in domestic economy, both as a fuel and for diet. I come now to what, I trust, may prove of far more value in a national point of view; I mean the great strength and staple of the woody fibre of the stalk of the sunflower, a part not heretofore applied to any use, except as above proposed by Mr. Saunders.

When we consider the immense importance of the article hemp to our maritime concerns, (other objects of its application out of the question,) and recollect what sums are annually expended in Russia in the purchase of this raw material; when we reflect, too, on the comparatively small proportion of our wants supplied amongst ourselves, partly arising from the trouble and uncertainty of the crop, and more, perhaps, from other articles of husbandry being more productive; we must admit, that if a fair and adequate experiment shall prove, that a plant, attended with little trouble in cultivation, and almost certain in its produce, is capable of affording a substitute for hemp, of equal or even superior strength for manufacturing ropes, cables, &c. of such infinite importance to the commerce, &c. of the United States;—I say, if this is demonstrated by fair experiment, who will doubt its becoming an article of the first attention in agricultural pursuits? The chief object of this essay is to call upon our farmers and others, especially those who are accustomed to raise hemp, to give this a fair and candid examination. In towns, we have not adequate advantages to pursue this enquiry; but it is now several years since I accidentally found a sunflower standing in my garden, of which little remained but the woody fibre, (the rain, &c. having gradually rotted off the epidermis, &c.) which resisted so much my attempts to break it, that I was forcibly struck with the probable advantages to be derived from its use. Since that time I have repeatedly mentioned the fact, and have endeavoured to induce others to pursue the enquiry, but, I believe, without effect. My attention has been again called to this subject, by lately stripping off a small and single fibre from a plant, and twisting it once or twice into a small twine, which I could not with all my force break, otherwise than by repeatedly bending, so as gradually to destroy the cohesion of the parts; even the *single* fibre would, I believe, have supported a weight of some pounds. Under the impression I have, I consider the medium of the *Emporium* the best, by which I might hope to have a full and fair experiment made upon a point so truly important, and I have only to request the favour of any one who pursues it, to let me know the result, that I may communicate it to the public.

Before I conclude, I shall only add, that the *pith* of this plant, which is very considerable, is, without exception, one of the most combustible materials I know. A piece of seven or eight inches in length, from one of the branches, perfectly dry, catches fire like tinder, and burns down in less than a minute. Whether experiment may show it to be useful as a match, in blasting rocks, instead of the present kind employed, I know not; probably we may find it useful in this, as well as in other pursuits.

THE IMPORTANCE OF DISTILLED WATER IN YOUR SURVIVAL STRATEGY

By George W. Preuss

THE PRE-CRASH REALITIES:

Water quality standards vary so much from community to community that they are often meaningless. There have been instances of towns and cities that said, "Approved Water Supply" only to have been giving their people contaminated water.

In theory, rivers are self-cleaning over large distances. In reality, after factories dump their wastes, cities pump in raw sewerage, and pesticides, herbicides and fertilizers get into the water it's not surprising that throat, bladder, and stomach cancers are higher in New Orleans after the Mississippi has been contaminated, than up north. Asbestos in drinking water can trigger intestinal cancer years later.

To avoid costly filtration techniques and avoid lawsuits for failure to kill bacteria, municipalities add large amounts of chlorine to drinking water. When chlorinated water is ingested with dyes, additives, preservatives and other chemicals in the American diet it's not uncommon to see increases in degenerative diseases. Bakeries and other food processing operations often use heavily chlorinated city water in their manufacturing processes.

Several decades ago when the aluminum industry was stuck with hundreds of tons of the toxic waste product, sodium fluoride, suddenly, by accident, fluoridization became very popular. The municipalities decided that they "knew what was best for us".

When inflation soared, and ocean front land became expensive, land developers and industries over-built. Natural fresh water aquifers were quickly depleted and could not recharge with fresh water. So salt water infusion occurred. Drinking water became salt contaminated. The great "American diet" often contains excessive amounts of refined sugar and food processors add salt "for flavor". Some sodium is necessary for life and for the potassium-sodium balance. (Ideally one should get natural sodium from foods like beets.) Unfortunately with a high sodium diet the body tends to excrete the needed potassium and hold the salt. After decades of abuse, hypertension and kidney failure are common.

Some health enthusiasts believe that "mineral water" has many beneficial trace elements. The body must then struggle to

remove the insoluble, inorganic minerals. If hard water or mineral water is allowed to evaporate the glass is often coated with a tough, crusty material similar to kidney stones. Trapped unusable inorganic minerals are deposited in essential body joints like elbows, knees, and feet. Mineral water is not distilled water.

Many Americans depend on well water. If the septic tank is too close or sewer lines leak, or if neighbors use herbicides there's a high probability of contamination. Well water often contains excessive amounts of iron, sulfur, calcium or bacteria. We've all seen one inch diameter water pipes that have become clogged with debris until only a fraction of the water flow can get through. Loosening the minerals requires a hammer.

Even if drinking water leaves the filtration plant free from impurities, additives, and bacteria the "safe water" must travel through miles of pipes, into water towers that never see sunlight, coming in contact with soldered joints or lead pipes. In our affluent society, last month's sewerage is last week's fresh water and next week's drinking water.

If your drinking water has a strange woody taste that's from the decomposed leaves. If there's oil in your water, blame the outboard motors on the lake. Whatever oil, antifreeze or other carcinogens that are on the pavement get washed into the future water supply with the first rain.

After a heavy storm or when the sewerage backs up into the fresh water supplies health officials tell the citizens to "boil the water". Although this is better than doing nothing and it kills some of the bacteria, the sad and funny part is that the pure, safe, distilled water goes off as vapor. The "boiled water" and all the inorganic residues in it are ingested, and the body has to work hard to get rid of the solid contaminants.

When you buy bottled-distilled water for \$1.00 a gallon Murphy's Law prevails. You have to take on faith the manufacturer's promise that he sterilized the container and used distilled water in it. Was the bottling plant next to a refinery? What about the bacteria count? How long ago was it distilled? Who has more interest in your water safety than you?

Distilled water should be stored in steam sterilized, glass containers with clean, tight fitting lids. Bottles should be

rotated on first-in, first-out basis. There are several important reasons why distilled water should not be stored in plastic containers, yet many manufacturers do this. The funny taste that distilled water gets when stored in plastic bottles is due to the molecular exchanges. In contrast to mineral saturated, hard water, distilled water is relatively contaminant free. It has a tremendous "pulling power" or attracts loose molecules. Inside the human body distilled water attracts waste products, accumulated chemical poisons and other debris and helps the body remove these toxins. Inside a plastic bottle, the distilled water begins leeching the loose plastic molecules and these are consumed when the water is used. Plastic being softer has surfaces for debris to get trapped. Glass can be sterilized with hot steam, while plastic gets soft or tacky.

DISTILLED WATER AND GOOD HEALTH

To the medical establishments it seems almost simplistic to blame drinking water for a myriad of illnesses when thousands of other causes may be relevant also. After decades of poor health habits, desperately ill people want to continue in their ways and "drink distilled water to get well".

When combined with adequate rest, exercise, fresh air, and moderation in diet, distilled water can help nature restore health. Routine maintenance is always preferable to major repairs. Drinking several large glasses of distilled water each day for 30 years is easier than risking kidney stones or bladder infections in the future. Glaucoma, kidney failure, dry skin, diabetes, constipation, senility, glandular malfunctions, and even aging itself; to what extent are these conditions merely symptoms of trapped, accumulated poisons in the body?

When one stops drinking tap water and starts on distilled water there is a tremendous surge of energy and a feeling of well being the first couple days as wastes are suddenly released. Approximately three weeks later as more and more toxins are released in the body and excreted there may be a short-term feeling of discouragement, but this passes quickly.

When cooked with distilled water in a stainless steel pan, soups or vegetables like green beans taste better. (Avoid aluminum pans, aluminum interferes with digestion, forms toxic salts, and is absorbed by the liver, kidney and brain.) Distilled water quenches thirst better than soft drinks. Alcoholics who resume a balanced diet and flush their bodies by drinking distilled water, discover that

liquor isn't as delicious as it used to be.

Embedded dirt in cuts can be soaked out with distilled water. It doesn't scar the way iodine does. As municipalities go bankrupt contaminated water will carry water-borne diseases. Dehydrated food that's reconstituted with distilled water has a better flavor and texture. Many prize winning race horses are given distilled water. (Could distilled water help your endurance?)

If distilled water helps in the digestion and assimilation of food, apply this idea to survival. Could people survive longer on the same amount of food, if they had adequate supplies of distilled water? Is vital body energy wasted trying to excrete water-borne poisons?

If big industry can use fraud to convince government to force us to consume fluoride, is it so unimaginable to envision population control policies implimented through the water system? The government would hold the "antidote monopoly" and sell licenses to raise revenues. (BRAVE NEW WORLD-1984 fans can imagine the "final solution" to the Social Security "problem".)

If water is contaminated with a substance that has a boiling point below 212°F (100°C) that must be distilled off first before the water is pure. If the glass bottles are not sterilized with hot steam and the machine is properly cared for,

there's always a possibility that some virulent bacteria on a dirty lid or able to survive the 212° temperatures might propagate.

- WATER DISTILLING UNITS:
1. Electric
 2. Fuel burning models
 3. Solar

They each have advantages and disadvantages. Owning one of each type is prudent.

1. Although the initial purchase price is high (often \$200 or more) the unit is neat, clean and easy to operate. The Aqua-Princess produces a gallon of water every 3 hours at under 10c per gallon.

International Pure Water Systems
U.S. National Headquarters
25 Edwards Court
Burlingame, California 94010
(415-348-5930)

It shuts off automatically. Since it pulls 1,000 watts and needs 120 volts you have to use a heavy duty extension cord. A frail lamp cord heats up.

Successful conversion of an electric distiller to fuel burning (underneath) would be difficult. The insulation and wires would be ruined.

2. Although fuel burning distilling units are easy to construct, most have no automatic shutoff. If the water boils away you may burn out the bottom of the still. It's best to have one still that's used only to purify water. You avoid chemical inter-

actions that make the water unsafe or unpleasant.

3. If everything goes wrong, it's wise to have in each survival kit a solar distillation kit. When deflated it measures 7" by 4" by 3" and produces about a quart of water daily. It distills sea water.

Write to:
Reliance Products
1900 Olympic Blvd.
Walnut Creek, CA 94596
(6038A Solar Distillation Kit \$29.95)
(\$1.50 shipping)

In Anthony Greenbank's THE BOOK OF SURVIVAL (New York: Perennial Library Harper & Row, Publishers, 1967 pages 57-58) he gives the details on using a bucket and 6 foot square plastic sheet to build a survival still. Dig the unshaded hole 3 feet across and deep enough to contain the bucket.

"Anchor plastic with soil and rocks at rim of hole. Place rock in center to weigh sheet down ... Plastic does not touch earth ... nor bucket. Vapor mist underneath sheet will show when condensation is forming ..."

This \$1.95 book is an essential to any survival library.

YEAR-LONG GOOSE

by Boyd Hill

In the south of France (Aveyron Province, not far from D'Artagnan's home in Gascony) the farmers keep enormous numbers of geese, both for food and to hold down the garden bug pests. This has led to a little-known method of preserving meat without refrigeration.

My wife, as a little girl, often ate such goose at her Grandfather's farm in Pradinhas. It was very rich and oily, but would keep extremely well over at least one summer, and possibly for several years. Cooked pork could also be preserved in the same manner.

It requires large (about 18" diameter by 24" high) earthenware jugs, heavily glazed inside ... and a great deal of clarified goose fat, mixed with clarified pork lard.

The goose can be cooked (thoroughly) in almost any way, but in Pradinhas was usually roasted on a spinning spit (a primitive rotisserie) in front of the kitchen fire. Alternatively it could be roasted whole in an oven, or cooked (essentially

deep fried) in chunks in the goose-fat/pork lard mixture.

A layer of fat/lard about an inch deep was put into the jar and allowed to solidify. Then the chunks of goose, about two-fist size, were placed in a layer in the jar. IT WAS IMPORTANT THAT THE MEAT DID NOT TOUCH THE SIDE OF THE JAR. Over the meat the hot fat/lard mixture was poured until it covered the meat about an inch. This layer was then allowed to harden, and the process repeated until about three or four inches from the jar's rim. Lastly, an inch-thick topping of pure pork lard was poured on as a sealer, and the whole thing covered with a piece of cloth tied on with string.

The preserved goose was called a "confit," and was usually kept in the cool cellar. However, the meat would stay fresh and wholesome (as long as it was completely covered with a fat/lard layer) for weeks or more in a hot summer kitchen.

To Pickle Gherkins.—Put about two hundred and fifty in strong brine, and let them remain in it three hours. Put them in a sieve to drain, wipe them, and place them in a jar. For a pickle, best vinegar, one gallon; common salt, six ounces; allspice, one ounce; mustard seed, one ounce; cloves, half an ounce; mace, half an ounce; one nutmeg, sliced; a stick of horse-radish, sliced; boil fifteen minutes; skim it well. When cold, pour it over them, and let stand twenty-four hours, covered up; put them into a pan over the fire, and let them simmer only until they attain a green colour. Tie the jars



To free Plants from Leaf-Lice.—The following is recommended as a cheap and easy mode of getting rid of this pest:—Mix one ounce of flowers of sulphur with one bushel of sawdust; scatter this over the plants infected with these insects: they will soon be freed, though a second application may possibly be necessary.



Cryptography, or secret writing—from the Greek *cryptos*, a secret, and *graphein*, to write—has been largely employed in state despatches, commercial correspondence, love epistles, and riddles. The telegraphic codes employed in the transmission of news by electric wire, partakes somewhat of the cryptographic character, the writer employing certain words or figures, the key to which is in the possession of his correspondent. The single-word despatch sent by Napier to the Government of India, was a sort of cryptographic conundrum—*Peccavi*, I have sinned (Scinde); and in the agony column of the *Times* there commonly appear paragraphs which look puzzling enough until we discover the key-letter or figure. Various and singular have been the devices adopted—as, for instance, the writing in the perforations of a card especially prepared, so as only to allow the real words of the message to be separated from the mass of writing by means of a duplicate card with similar perforations; the old Greek mode of writing on the edges of a strip of paper wound round a stick in a certain direction, and the substitution of figures or signs for letters or words. Where one letter is always made to stand for another, the secret of a cryptograph is soon discovered, but when, as in the following example, the same letter does not invariably correspond to the letter for which it is a substitute, the difficulty of deciphering the cryptograph is manifestly increased:—

Ohs ya h sych, oayarsa rr loucys syms
Osrh srre rrrhmu h smmsmah emshyr
snms.

The translation of this can be made only by the possessor of the key.

a b c d e f g h i j k l m n o p q r s
h u s h m o n e y b y c h a r l e s h
t u v w x y z
r o s s e s q

“Hush Money, by Charles H. Ross, Esq.”—twenty-six letters which, when applied to the cryptograph, will give a couplet from Parnell’s “Hermit”:—

“Far in a wild, unknown to public view,
From youth to age a reverend hermit
grew.”

The employment of figures and signs for letters is the most usual form of the cryptograph. From the following jumble we get a portion of Hamlet’s address to the Ghost:—

9 a 6 2 x † 9 a 1 | 3 a 3 † 2 † * 7 6 †
9 5 2 1 2 7 2 a 1 ; †
4 2 8 * ; † (3 † 3 , * 7 8 2 9 x , 1 * †
6 * 4 x 3 a 1 9 | a 2 1

HANG-FIRE

by Kurt Saxon

Anyone who has played with firecrackers or higher explosives understands the term, “hang-fire” In case you haven’t, hang-fire means a fuse has seemingly gone out, yet smoulders. The experienced will wait several minutes to make sure the fuse has died. But the novice will pick up the object to relight the fuse, only to have it resume burning and go off in his hand.

For many years demographers, those who study human societies and where they are headed, have been warning of civilization’s eventual collapse due to a surplus of people. Worse than a mere surplus is the increasing inferiority of so many being born today.

As the educated and employed limit their births the ignorant on welfare go on having as many babies as biology allows. They have swamped our civilizations until crowding, pollution, inflation, violent crime, etc., has lowered everyone’s standard of living.

Over the years, such professional men as Dr. Paul Ehrlich, Garrett Hardin, William and Paul Paddock, Karl Sax, William Vogt and many others have warned of the consequences of uncontrolled fertility among homo-sapien populations. Their warnings were studied and logical. However, all too often, they endangered their credibility by dating their predictions.

The problem with dating such projections is that unforeseen variables implemented from within or from without a stricken culture can make the prediction and the predictor seem wrong.

William and Paul Paddock’s book predicted “Famine—1975!” Although in 1975, conditions in third-world countries were worse than in 1967, when the book was published, technology and economic juggling averted actual famine on a broad scale. Of course, malnutrition was more common in 1975 than in 1967 but since this best-seller’s titled date was premature, its warnings were ignored.

Famine did hit in Africa’s Sahel region in the mid-’80s. Millions starved and are still starving. Idiots wanting such predictions to be wrong blamed the famines, not on the surplus populations, but drouth. There was no exceptional drouth. The famine was, and is, being caused by desertification.

A desert is an area whose ecology does not create its own rainfall. The Sahel is a band of desert stretching nearly across the whole of the continent of Africa. It has been widening at a rate of five miles a year. Ignorant primitives, overgrazing the grass and brush and cutting down the trees for fuel, have been creating their own desert out of a once verdant area.

Years before the famine, the natives were given all the benefits of modern science to save more of their useless offspring, as well as the offspring of their cattle, goats and sheep. Those offspring grew to have all the offspring they could. So, as they all chewed and hacked away at the vegetation, the desert widened and millions starved.

In 1985 the famine was a media event. One could not avoid specials showing pot-bellied, skeletonized children who should not have been born in the first place. The most disgusting scene I can remember was of a woman at one of the feeding stations leaning against a wooden fence, while having yet another baby. On the other side of the fence were crowds of starving natives not lucky

With the key—

a b c d e f g h i j k l m n o p q r s
9 4 5 1 2 7 6 8 3 + - x | a * () † ‡
t u v w x y z
, ; : . 0 \$ ÷

it is easy to write and not very hard to read the entire speech. The whole theory of the cryptogram is that each correspondent possesses the key to the secret. To confound an outside inquirer the key is often varied. A good plan is to take a line from any ordinary book and substitute the first twenty-six of its letters for those of the alphabet. In your next cryptogram you take the letters from another page or another book. It is not necessary to give an example. Enough will be seen from what we have written to instruct an intelligent inquirer.

TOYS TO DELIGHT THE CHILDREN

HOME WORKSHOP MANUAL 1930

The pressing problem of keeping children off the street, with its thousands of dangers, is most serious. With a playground like this it is not difficult to interest the children at home, and their playmates are always glad of an opportunity to be with them.

The playground contains a trapeze, swing, rings, tent, teeter-totter and flag-pole; an airplane that runs on a wire 100 ft. long and gives a real thrill; and a tank for miniature boats, which every mother will appreciate because almost all boys insist on using the bathtub for this purpose. The apparatus is painted white and trimmed in green. Incidentally, the machine gun, sailboat, battleship and windmill are all homemade toys.

In purchasing the lumber for playground apparatus, choose clear, straight-grained oak and yellow pine for all parts that must be strong and durable. Common grades of spruce and hemlock are cheaper, but you will experience a great deal of difficulty if you purchase them for this work. Strength and durability are of the utmost importance in this work.

The materials necessary for the trapeze, swing and rings are as follows: 1 pc. 1 by 2 in. by 12 ft., 1 pc. 2 by 3 in. by 8 ft., and 4 pcs. 2 by 2 in. by 8 ft., all oak; 1 pc. $\frac{3}{16}$ in. by 1 in. strap iron, 6 ft. long; 16 carriage bolts, $\frac{5}{8}$ by $3\frac{1}{2}$ in.; 2 carriage bolts, $\frac{5}{8}$ by 5 in.; 2 carriage bolts, $\frac{1}{2}$ by 5 in.; 2 pcs. $\frac{1}{2}$ -in. gas pipe, 4 in. long;

enough to have gotten inside the feeding station.

Incidentally, the famine didn't go away. It just became boring as Americans wasted more and more money to stave off the inevitable doom of millions of useless primitives.

The TV evangelists were the worst offenders in the media hype. As I remember, Jimmy Swaggart raised \$300,000.00 before he was assured the food would not be delivered. Even so, he went on to raise a total of \$3,000,000.00, none of which went to Africa.

The most ridiculous example of misplaced compassion was the New York school project where little children, many on welfare, were urged to give their nickles and dimes for an airlift of grain to the famine area. I worked it out and the one planeload of wheat cost over \$3,000.00 per ton. Such foolishness only makes people more callous to human suffering.

At any rate, William and Paul Paddock were right. But since they were premature, their warnings were discounted.

Dr. Paul Ehrlich's "The Population Bomb" was published in 1968. In this book he predicted the worst in nine years, or 1977. His observations were correct but his time calculations were off. So he, too, was considered a harmless alarmist. Although his findings assured doom for most of mankind and were based on the laws of cause and effect, he too, was ignored. The prologue of "The Population Bomb" is reprinted below.

PROLOGUE

The battle to feed all of humanity is over. In the 1970's the world will undergo famines—hundreds of millions of people are going to starve to death in spite of any crash programs embarked upon now. At this late date nothing can prevent a substantial increase in the world death rate, although many lives could be saved through dramatic programs to "stretch" the carrying capacity of the earth by increasing food production. But these programs will only provide a stay of execution unless they are accompanied by determined and successful efforts at population control. Population control is the conscious regulation of the numbers of human beings to meet the needs, not just of individual families, but of society as a whole.

Nothing could be more misleading to our children than our present affluent society. They will inherit a totally different world, a world in which the standards, politics, and economics of the 1960's are dead. As the most powerful nation in the world today, *and its largest consumer*, the United States cannot stand isolated. We are today involved in the events leading to famine; tomorrow we may be destroyed by its consequences.

Our position requires that we take immediate action at home and promote effective action worldwide. We must have population control at home, hopefully through a system of incentives and penalties, but by compulsion if voluntary methods fail. We must use our political power to push other countries into programs which combine agricultural development and population control. And while this is being done we must take action to reverse the deterioration of our environment before population pressure permanently ruins our planet. The birth rate must be brought into balance with the death rate or mankind will breed itself into oblivion. We can no longer afford merely to treat the symptoms of the cancer of population growth; the cancer itself must be cut out. Population control is the only answer.

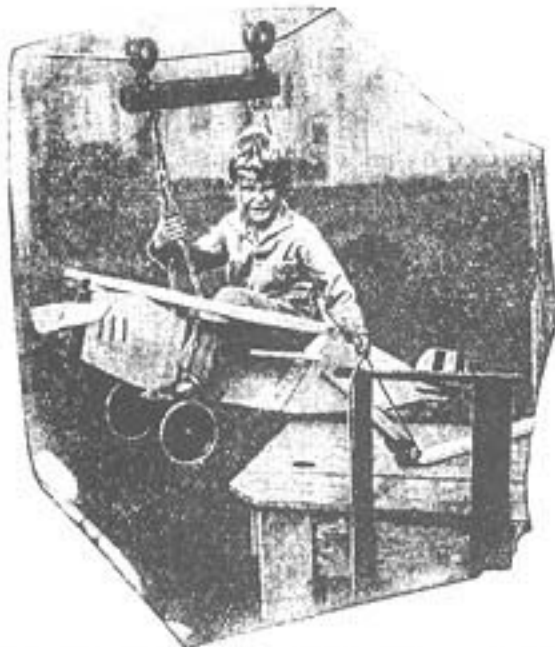


FIG. 28.—This airplane, sliding down a 100-ft. wire, will provide a genuine thrill without danger, if properly constructed.

4 washers, $\frac{1}{2}$ in.; 6 porch swing hooks; 1 set porch swing chains; 2- $\frac{1}{2}$ -in. eye-bolts. It simplifies the construction greatly if you have a planing mill cut and plane the lumber to finished sizes.

First cut the 2 by 3 in. crossbeam to a length of 7 ft. and bore a $\frac{5}{8}$ -in. hole 30 in. from each end. Now lay out the four 2 by 2 in. legs, which are 7 ft. 10 in. long. Cut the upper end of each on an angle so that they will spread 6 ft. 8 in. apart at the bottom. When in place, bore a $\frac{5}{8}$ -in. hole at the upper end of each, $1\frac{1}{2}$ in. from the top, to correspond with the holes in the crossbeam; also bore a $\frac{5}{8}$ -in. hole 13 in. from the upper end. Cut two 1 by 2 in. braces 32 in. long and bore a $\frac{5}{8}$ -in. hole $1\frac{1}{2}$ in. from either end. Bolt them in place as indicated in Fig. 29. Cut four pieces of the 1-in. strap iron 18 in. long, drill a hole in each end, and bolt them in place. Cut two 1 by 2 in. pieces 28 in. long and bolt them 20 in. below the top of the crossbeam. Place the six screw hooks in the crossbeam exactly at the locations shown in the drawing.

Cut two chains 70 in. long for the swing. The seat is a piece of 1 by 6 in. oak 18 in. long. Bore holes for the two eyebolts and fasten the chains in place.

The trapeze is made of two pieces of chain 32 in. long and a broomstick grooved to hold them. Merely widen the end link of each chain, slip it over the end and bend it back in the groove.

For the rings cut two pieces of chain 32 in. long and two pieces 7 in. long. Join these to form a V. Next take one of the 5-in. bolts, slip a $\frac{1}{2}$ -in. washer over it and put it through one side of the chain. Slip the bolt through one of the 4-in. lengths of gas pipe and out on the other side of the chain; add another washer and the nut. In finishing the ap-

Of course, Paul Ehrlich was often featured on the Johnny Carson Show. This was a mixed blessing. He did reinforce his arguments and sold a lot of books. But he is so genial and sophisticated in his delivery that he makes Johnny's largely moronic viewing audience feel superior to such an egghead.

I was on the Phil Donahue Show in June of 1980. I told what was happening to world civilization and was treated to jeers and angry shouts. I loved it.

In 1980 there weren't nearly 4,000,000 homeless in the U.S. with 60,000 in New York City alone. Family farms weren't going under at the rate of 380 per day. Banks weren't failing all over the place. Businesses weren't going bankrupt at a record rate. GM announced the closing of ten more plants in the next three years. More work is going out of the country, even as more Latin Americans are sneaking across the Rio Grande.

But everything is being worked out, the politicians, their economists and the media tell us. This is because broadcasting the truth would cause a panic. Politicians who can't do anything, anyway, wouldn't get reelected. Media ads for trash wouldn't pull, so the TV stations would lose revenue.

Sure, there's many reasons the Establishment wants people to go on going on with business as usual, what there is of it. So everyone who warns that this Disneyland for dummies is going to close down soon must be discredited.

Really, what good does it do the average person to tell him that his culture medium is coming apart; that the degeneration of civilization, since the early '70s, has accelerated past the point of no return? What can he do about it?

I don't blame the politicians and the media for propping up their doomed Establishment as long as they can. Some of them do believe there are solutions. But most of them know there are no solutions and are only buying time to get themselves a secure haven in which to wait out the coming storm.

But all the billions in inflated currency pumped into our economy and all the media deception will only serve to make the collapse worse when it finally comes. As I was writing this I was watching a news story about retired workers protesting their loss of pensions as the companies they had worked for went bankrupt. They had swallowed the nonsense about a safe and secure retirement. Now they have nothing but insecure Social Security to fall back on.

Soon people will be surprised to see that their bank accounts will not be covered for up to \$100,000.00 as promised by the FDIC. If your bank fails and your house payment comes due, the few thousand in your account will be gone and you could soon join the ranks of the homeless.

Of course, if you've planned ahead and decided to relocate with a useful trade, you can avoid the worst. But maybe it's easier for you to put your faith in others rather than in yourself.

At any rate, the hang-fire principle is about to smoulder toward the live part of the socio-economic fuse. More people are acknowledging the active sputter. September 10's CBS Report, "Examining The Federal Deficit", showed Federal Reserve Board Chairman Alan Greenspan predicting a recession by 1989. What he calls a recession will make the Great Depression seem like a time of affluence.

paratus, you can use either white paint or spar varnish.

The boat tank (Fig. 30) is so simple in construction that it is hardly necessary to go into any details. The materials necessary are: 3 pcs. 1 by 12 in. by 8 ft., 1 pc. 1 by 12 in. by 2 ft., 1 pc. 1 by 6 in. by 3 ft., and 1 pc. 1 by 4 in. by 8 ft., yellow pine or cypress.

Square up the 1 by 12 by 8 ft. pieces and plane to a smooth edge. Cut the two ends $10\frac{1}{4}$ by $11\frac{3}{4}$ in. and nail ends and sides together. Now take the other 8-ft. board and nail it in place for the bottom. It is well to put a heavy coat of white lead on the edge of the sides and ends before the bottom is nailed in place. This will insure a more waterproof tank. Now cut four 1 by 4 in. pieces 16 in. long; nail them on the four corners to form the legs. Cut a 1 by 4 in. piece to fit across the top of the tank at each end to reinforce it and keep it from spreading. Cut two 1 by 6 in. pieces and nail in place across each end at the top. Bore a 1-in. hole 1 in. from the top to keep the tank from overflowing.

While the construction of the airplane (Figs. 28 and 31) is comparatively simple, it must be built up properly or it will be dangerous for the smaller children. The landing gear and tail skid must be strongly built so that the plane will not be broken when it lands.

The materials necessary are: 1 pc. 1 by 12 in. by 12 ft. yellow pine; 1 pc. 1 by $1\frac{1}{2}$ in. by 10 ft. oak; 1 pc. 2 by 4 in. by 3 ft. yellow pine; 2 pcs. $\frac{3}{16}$ by 1 in. strap iron, 18 in. long; 1 set of porch swing chains; 4 screw hooks, 1 in.; 2 disk wheels, 5 in.; 100 ft. No. 9 galvanized wire; 2 pulleys, $1\frac{1}{2}$ in.

The wing, which is 4 ft. from tip to tip, and the fuselage, which is 4 ft. 3 in. long, are cut from 12-in. board. Join the wings and fuselage with $1\frac{1}{2}$ -in. wood screws. Cut an 18-in. piece of two-by-four and fasten it to the bottom of the fuselage or body directly under the wing to form the axle or landing gear. To this attach the wheels next. If you can't obtain disk wheels conveniently, saw out wheels of 1-in. oak. Be sure the landing gear and wheels are strongly made. There is considerable strain on these parts when the ship lands. Fasten the two pieces of 1-in. strap iron in place to brace the landing gear.

The tail skid is made of two 15 in. long pieces cut from 1 by $1\frac{1}{2}$ in. oak and bolted in place on the fuselage. As this is used as a brake in stopping the airplane, be sure that it is firm.

You will notice in the drawing (Fig. 31) that the fuselage also is reinforced

close
up

CBS REPORTS
9 PM 5 6 7 10 13

EXAMINING THE FEDERAL DEFICIT

Lesley Stahl reports on the Federal deficit in a program that, says producer Brooke Janis, considers "the consequences of that mountain of debt that we're building up." The hour, still being assembled at press time, is slated to include:

- ☐ Economics correspondent Robert Krulwich using "Leave it to Beaver" clips to illustrate how the average family's standard of living has dropped since the 1950s. Included are comments from Federal Reserve Board chairman Alan Greenspan.
- ☐ Investment banker Felix Rohatyn on Japan's rise as an economic leader.
- ☐ Lowans at a Federal deficit seminar.
- ☐ Three Presidential hopefuls—Sen. Robert Dole (R-Kan.) and Reps. Richard Gephardt (D-Mo.) and Jack Kemp (R-N.Y.)—commenting on the economy.
- ☐ A summary, in which Stahl says that it's the "lack of concern for the common good that's brought us to the edge of this invisible crisis."

close
up

ONLY ONE EARTH
8 PM 6 13 21 28
TUES. 7 PM 6
WED. 8 PM 13



Senegalese children: will there be land for them to farm?

Debut: An 11-part British series assessing the earth's ecological past and future.

The opener travels along "The Road to Ruin" in three countries: Senegal, where "over-farming" is damaging the long-term agricultural outlook; Mexico, where ranches and oil refineries are encroaching on rain forests; and Scotland, where fish populations are threatened by mechanized harvesting. (60 min.)

On September 7, PBS showed the first of an eleven part series entitled "Only One Earth", assessing the earth's ecological past and future. The opener, titled "The Road To Ruin" backed up most of what I've been writing in The Survivor.

So now, at the 11th hour, the government and the media are telling it like it is; as I've been doing for years. Either they are reviving a latent conscience or they want to absolve themselves of blame by being in a position to say "I told you so".

Regardless, you should know by now that the hang-fire period in our final years as a great and prosperous nation is about to end in an as yet unimagined explosion. But you still have time to save yourself and some of what is the best of our culture. Whether you will or not is up to you. However, if you consider your line worthy to continue, you will draw on your ancestors' determination to survive and cut all ties to this present order.

If you have living descendants a hundred years from now, you will be remembered as a credit to your species. If not, you won't be remembered at all. But that too, will be good for our species.

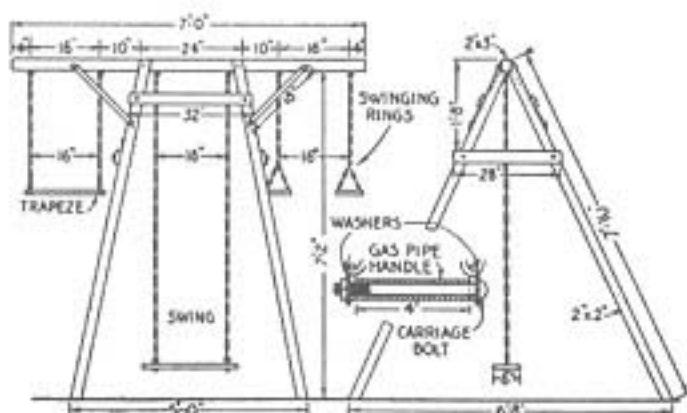


FIG. 29.—The frame for the swing, trapeze, and rings is made from planed lumber and bolted together. Porch swing chains and hooks are used.

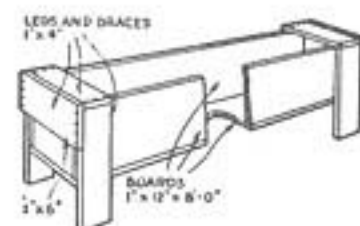


FIG. 30.—Be sure that the edges of the boat tank boards are heavily coated with white lead before being nailed together. This will be of help in making the joints water-tight.

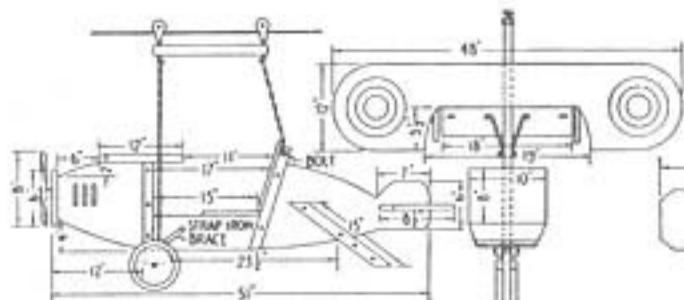


FIG. 31.—The dimensions for the airplane. Make sure that the chains are securely fastened, and adjust the toy so that the tail skid strikes the ground first, acting as a brake.

with 1 by 1½ in. strips. Cut two pieces 14 in. long and fasten them on each side of the fuselage in back of the seat. They extend about 2 in. above to give a place for attaching the rear chain. Bolt two pieces of wood 12 in. long between the axle and the wing just ahead of the cockpit.

The seat is made of any light wood and cut as shown in the drawing. The tail is made of two pieces 1 by 3 by 8½ in., cut as shown, and nailed in place. The radiator is a piece of oak 1 by 1½ by 6 in., held in place with two screws. The propeller is cut from white pine and pivoted on a 2-in. wood screw.

A porch swing chain set usually contains two large hooks; these are screwed into the 2 by 4 in. axle for the two front end chains.

In painting the airplane you can use any colors you desire. The one illustrated is white, with red, white and blue targets on the wing and a black radiator.

The trolley is made of a piece of 1 or 1½ by 1½ by 16 in. oak. Screw two hooks above and two on the underside. Slip the pulleys in place and, to make certain they will not come loose, bend shut the hooks that hold them. The lower hooks are left open so that the chains can be adjusted to the desired height.

Now comes the most interesting part of the whole job—making ready for our test flight. Take 100 ft. of No. 9 wire, slip the pulleys into position, and stretch the wire from the house to the garage, or to a tree or any other suitable place. It is not necessary to have the upper end to any great height; a very small incline will give sufficient speed to thrill any youngster. After the wire is stretched, fasten the airplane to the hooks and adjust it so that the tail skid will come in contact with the ground before the wheels touch. This will bring the airplane almost to a complete stop before it reaches the lower end of the wire. It is well to use a turnbuckle at one end of the wire, as from time to time it will be necessary to take up the slack.

The teeter-totter (Fig. 32) is a very simple piece of apparatus, but it will give the children endless pleasure. The materials: 1 pc. 1 by 12 in. by 8 ft., 1

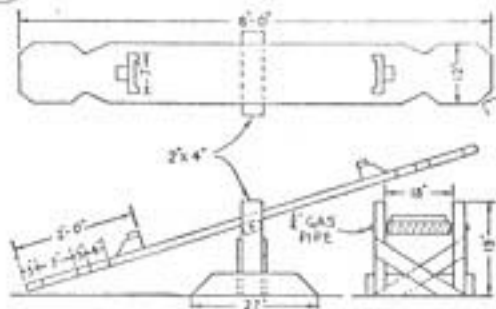


FIG. 32.—Make sure that the gas pipe shaft cannot work out and allow the teeter-totter to spill the children. Two cotter pins will prevent any danger of such an accident.

pc. 2 by 4 in. by 12 ft., and 1 pc. 1 by 4 in. by 8 ft. yellow pine; 1 pc. of $\frac{3}{4}$ -in. gas pipe (about 1 in. outside diameter) 24 in. long.

First cut out the 1 by 12 in. by 8 ft. board as shown in the drawing on page 98. Nail or screw across the board at the center one piece 2 by 4 by 17 in., after boring a 1-in. hole through it from end to end. Cut two pieces for uprights 2 by 4 by 19 in. long and 5 in. from the top of each bore a 1-in. hole. Cut two pieces 2 by 4 by 27 in. to form the base and nail them in place as shown. Cut one piece of 2 by 4 by 18 in. and nail it between the uprights at right angles with the base. Now brace the stand with two 1 by 4 in. pieces as indicated in the diagram. Place the top board in position and slip the pipe through the uprights and through the hole in the cross member, cotter pinning it in place. The handles are made of 1 by 1 by 7 in. pieces with a small block of 2 by 4 in. as the base.

SAND-BOX PLAY SHELTER

Playing in the sand never loses its fascination for small children. Give them a roomy sand box in a shady spot and they will amuse themselves endlessly.

To build a combination sand box and play shelter is a very simple task. A



FIG. 37.—Children have endless fun playing in an awning-covered box such as this one with its two removable seats.

few two-by-fours and odds and ends of boards, and an old tent fly, tarpaulin or awning are the only materials needed. As no fixed dimensions or methods of construction have to be followed, the builder can easily adapt the design to suit whatever materials are at hand. Two types of play shelters are illustrated in Figs. 37 and 38, and either can be modified or elaborated in many ways.

The shelter shown in Fig. 37 consists of a large sand box with two posts, which support a framework of 1 by 2 in. strips covered with canvas.

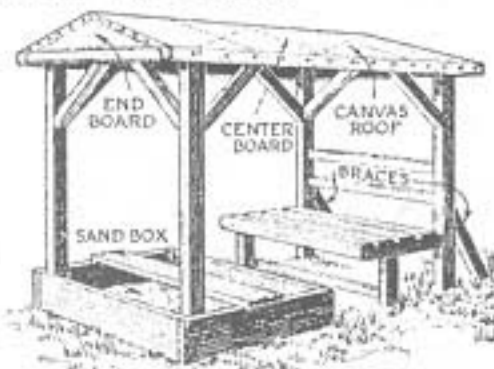


Fig. 38.—A play shelter that can be made quickly and cheaply from odds and ends of lumber.

Two removable standards, which fit over the sides of the box, support a length of pipe. This will serve as a safe horizontal bar, but its main purpose is to carry a simply made swinging seat. The standards and seat can be lifted up bodily and placed outside the sand box, when desired.

Another low seat, a trifle wider than the box, is made with cleats under each end, so that it can slide back and forth on the edges of the box. This is for the children to sit on, if they wish, while playing with the sand.

The other shelter (Fig. 38) is more like a miniature arbor, half of

which is occupied by a sand box and the other half by a seat.

No matter what construction is used in building a sand box, it should be given two coats of paint, either dark green or a color to harmonize with the near-by house.

It is important to have clean white beach sand for the boxes. When this cannot be obtained locally, a few bags can be bought from a dealer in masons' supplies or often from large department stores, especially in the cities.

TOY WOODWORKING MACHINES

The miniature motor-driven workshop machines shown in Figs. 39-44 consist of a lathe, drill press, sander-jointer, and circular saw. They not only serve as educational toys for children having a mechanical turn of mind, but will actually turn out work that is accurate enough for model parts and small toys. The cost of building these machines is negligible.

The lathe (Fig. 39) has an over-all length of 14 in., but the builder can increase it up to 24 in. successfully, if desired. The spindle is held in bronze bearings, which are split to facilitate tightening when they become loose. A model-T Ford front axle steering spindle body bolt was used for the spindle. As the bolt is $\frac{1}{2}$ in. in diameter, it allows the use of standard chucks and face-plates such as are sold by many of the manufacturers of portable type woodworking machines.

In preparing the bolt, remove the bolt-head just below the oil groove and smooth up the cut with a file. The straps that hold the spindle bushings in place can be made from $\frac{1}{16}$ -in. sheet brass or strap iron.

In a small lathe of this type there is very little thrust, therefore a small brass washer placed between the pulley and the end bearing block will serve the purpose of a thrust bearing.

In setting up the spindle, great care should be taken to see that the bearings are in line and that the spindle is allowed to turn easily.

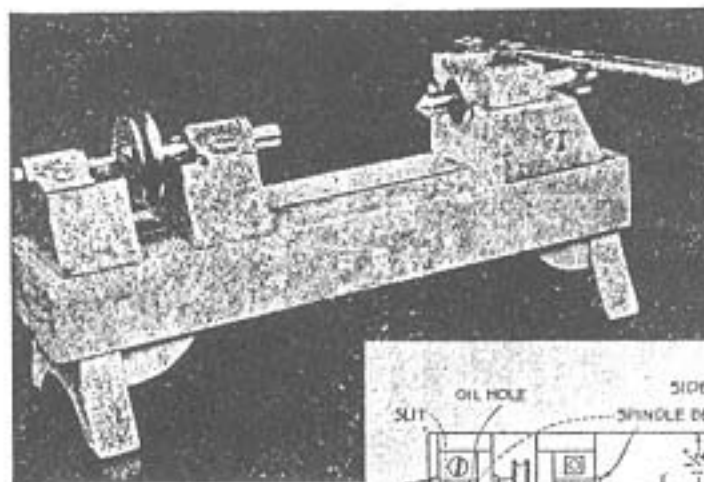
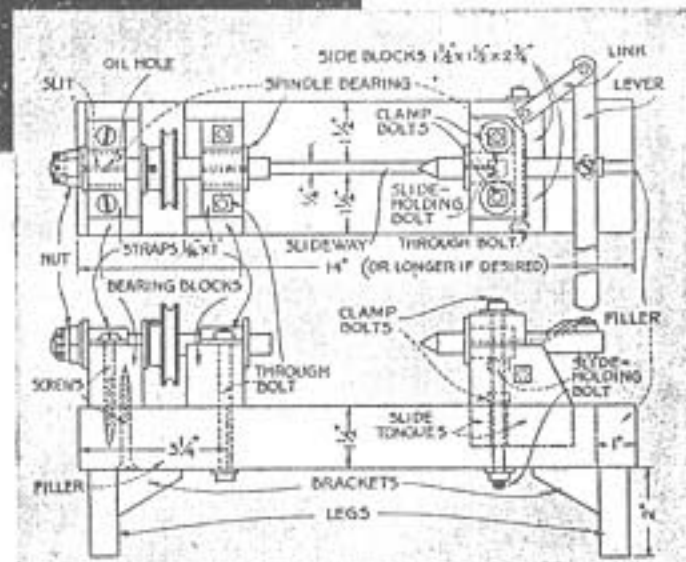


FIG. 39.—Aside from being a toy reproduction of a lathe, this small machine can be used in making ship model sheave, capstans, and the like.



This small lathe is a fascinating toy of considerable educational value. The materials cost little, but the machine can turn out real work with accuracy.

The dead center is of the lever controlled variety. The lever is made from a $\frac{1}{4}$ by $\frac{5}{8}$ by 8 in. strap-iron piece, and is held in place with $\frac{3}{16}$ -in. stove bolts, cut off at the right length and riveted over. The tailstock, which has a slide bolt for locking the stock at any position on the ways, is made from five pieces of wood: the two main pieces, the clamp for holding down the spindle bushing, and the two spacing blocks.

Finish the wooden parts of the lathe with two coats of shellac and then enamel to suit.

The base and brackets of the drill press (Fig. 40) are cut from $\frac{3}{4}$ -in. wood while the frame is made of $\frac{7}{8}$ -in. stock. The table, which is supported by a spool, is cut from $\frac{3}{8}$ -in. stock to a diameter of $2\frac{1}{2}$ in. The two arms are made from $\frac{1}{8}$ -in. strap iron and are bolted to the top of the frame as shown.

Iron washers are put between the pulleys and arms to serve as bearings. On the inner sides of the spool pulleys is

a disk of sheet tin, $1\frac{3}{4}$ in. in diameter, which serves to keep the belt from running off of the pulley. The shafts, on which the pulleys run free, are made from $\frac{3}{16}$ -in. nails cut to the right length and slipped through holes in the arms.

The spindle is a $\frac{1}{4}$ -in. rod $4\frac{1}{2}$ in. long. Its bearing is made by first boring a $\frac{1}{2}$ -in. hole in the arm (spool) and afterwards greasing the spindle and centering it in the hole. Melt some babbitt in a ladle and pour it in around the spindle. In this way the bearing is formed right in place and around the spindle.

The chuck was taken from a small drill of the hand variety that can be bought in many five-and-ten-cent stores. It is soldered and pinned to the end of the spindle.

A coil spring is slipped on the chuck spindle, as shown, and serves to keep the chuck raised when no pressure is applied to the knob on the top.

The circular saw (Figs. 41 and 42) uses a small, thin $2\frac{1}{2}$ -in. diameter metal saw, since woodworking saws are not ordinarily made in such a small size.

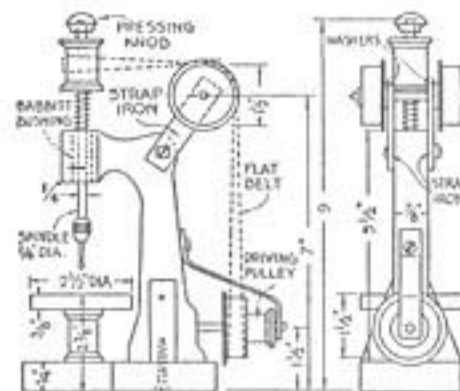


FIG. 40.—The miniature drill press. The chuck, taken from a hand drill of the spiral type, is pinned and soldered to the spindle.

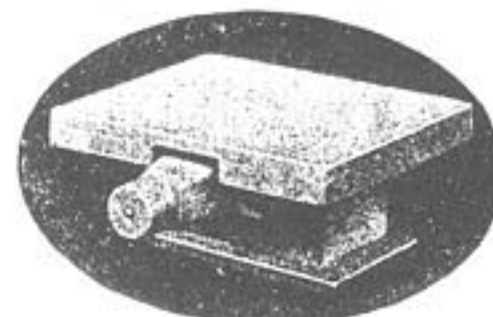


FIG. 41.—As small circular wood saws are practically unobtainable, a $2\frac{1}{2}$ -in. diameter metal saw is used.

The bearing for the saw spindle is molded of Babbitt metal in a wooden mold cut to the size and shape desired.

With a fine-tooth hack saw, slot the front half of the bearing; this will offer a means of taking up the bearing wear. The spindle is a $\frac{1}{4}$ by $4\frac{1}{2}$ in. long steel rod, threaded for a distance of about $\frac{3}{4}$ in. on the inner end.

The saw is held in place by putting a right-handed nut on the spindle, then the saw and another right-handed nut.

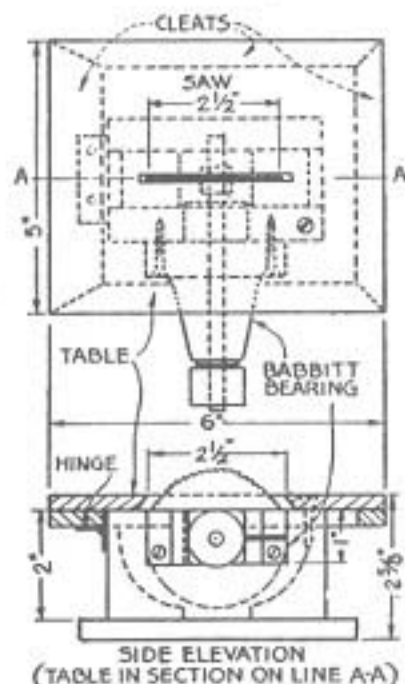


FIG. 42.—The babbitt bearing is cast in one piece in a wooden mold and is then split.

This will hold the saw firmly in place and will allow any adjustments that may be necessary.

The table top is hinged to the frame with a 1 by $1\frac{1}{2}$ in. hinge.

After the frame and top have been made, the bearing put in place, and the belt to the countershaft connected, raise the table and attach the saw blade. Start the motor and lower the table on the saw. In this way the blade will cut its own slot and thus will be assured of an accurate fit.

No ripping fence or miter guide is shown because a piece of wood clamped to the table top with C-clamps serves

the purpose.

The drum sander (Figs. 43 and 44) is so constructed as to represent an actual bench jointer. The frame is cut from $\frac{1}{4}$ -in. stock while the centerpieces are made from $\frac{5}{8}$ -in. Cut the slot in the table by sawing from the back at an angle of forty-five degrees. A mold for the bearing is made from wood, and the metal melted and poured. After the bearing is cold, saw the bar in half and drill for the spindle. Fasten the bearing in place with $\frac{3}{16}$ -in. countersunk machine screws.

The spindle is made from $\frac{1}{4}$ -in. rod and is $3\frac{3}{8}$ in. long.

The sander drum is 1 in. long and $1\frac{1}{16}$ in. in diameter and has a $\frac{1}{16}$ -in. hole

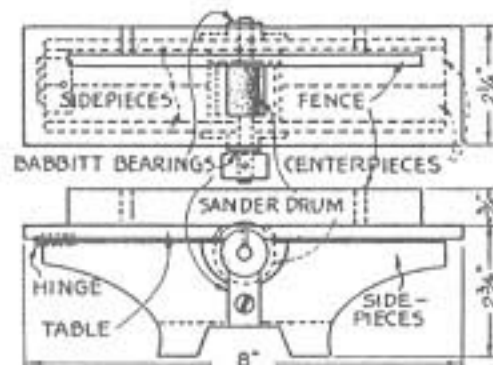


FIG. 44.—Details of construction of the drum sander shown in Fig. 43.

for the pin which is made from a nail. The sandpaper is cut in convenient strips 1 in. wide and is glued on the drum.

The proper height for the sander drum to project above the table top can be found by a process of trial.

The belts can be made by using the leather obtained from a man's leather belt of the cheap variety. The only specification is that the leather be soft and flexible.

If any of the belts tend to slip, a few turns of tape on the pulleys will help to remedy the trouble.

The machines can be painted with a silver-bronze paint for the table tops and a gray enamel paint for the frames.

HOMEMADE COASTER

Few recreational devices afford children more wholesome pleasure than a well-made wheel coaster. Incidentally, this motor-car type of toy gives them sound preliminary training in steering, braking, and road rules long before they are permitted to take the wheel of the family car.

Although the design illustrated in Figs. 47 to 50 is not self-propelled, it is so light and runs so easily that in level sections it can be pushed with little effort at a brisk speed.

Past experience in making several coasters of this type has made it possible to eliminate most of the faults of its predecessors, namely, unnecessary weight, a tendency of the steering cable to become loose, and unreliable brakes.

Lightness is achieved largely through using a $\frac{7}{8}$ -in. red cedar board for the "main frame," and bracing it underneath with a long $\frac{7}{8}$ by 3 in. truss or rib. The wood axle bars are of white pine, which is light and not likely to split; but they could be of oak, maple or other hardwood. They are grooved to receive the steel axles, which are held snugly in place by several 1-in. No. 15 ($\frac{1}{4}$ -in. diameter) flat-head wood screws and four end blocks and collars, as shown. The tendency of the ordinary coaster to come apart is overcome by using screws and bolts throughout the construction instead of nails.

Build up the hood framework as indicated. Place the seat and determine the proper angle for the steering post by fitting them to the prospective pilot. This is important.

In this case cold-rolled shafting $\frac{3}{4}$ in. in diameter was used for the steering post, but gas pipe would do as well. By no means use a broomstick or any kind of wood, as in a spill it might break off and cause serious injury. A regular automobile steering wheel can be picked up for half a dollar at any wrecking yard. If you have no breast drill, you may have to call on some friendly garage mechanic, blacksmith, or machinist to put the cotter-pin holes through the shaft inside the dash and to pin on the steering wheel, although the latter may be driven on a tapered end to make a tight fit. The front end of the steering post rests in a hole bored in a footblock which is about 2 by 6 by 8 in.

Use white pine for the steering-cable drum if you have to carve it out yourself, but hardwood in case you are able to turn it on a wood lathe. In either case, fasten it in place on the steering post by a pin or a long wood screw; or, if you prefer, drive it into position, provided the hole in the center is a tight fit on the shaft.

The sash cord used for the steering cable in other models always would stretch and become loose, but in this car a flexible woven wire cable was used with signal success. After once being drawn tight and well fastened it remained secure. As the cable is wound on the drum at right angles, it has no tendency to climb or slip down. A pulley $1\frac{1}{4}$ in. in diameter is screwed to the floor board at the correct angle to take the cable without being cramped. The cable is further guided by holes bored

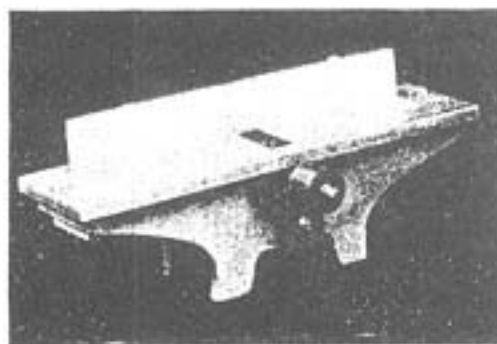


FIG. 43.—The drum sander is designed to look like a jointer of the commercial motor-driven bench type.

in the floor board and in the short piece of wood underneath.

The type of equalizing brake shown will lock the wheels at almost any speed, and as the coaster is light, there is small hazard in "cutting her wide open" on hills. If the brakes are well made, they are not likely to fail in any emergency.

It is important to fit a section of split hose over the sharp edge of the sheet-iron seat back, so that there will be no

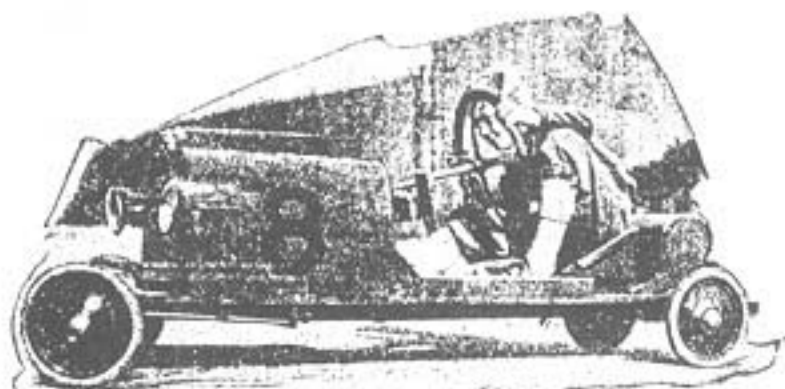


FIG. 47.—A low center of gravity and a wide tread make for safety when turning curves at high speed.

danger of getting cut in a crash. Brass wire is used to lace it to the seat back through holes punched with a nail.

Wheels, of course, are something that must be bought, and represent most of the expense, unless you have an old set on hand. It will be well to get the best you can buy, the disk type being preferable. On the coaster illustrated the wheels are 11 in. in diameter, with caged roller bearings, and give splendid service. Some boys maintain they can get greater speed out of the old style wire-spoke wheels with steel tires, but they make an unearthly racket, and have not the braking efficiency of rubber-tired wheels.

A pair of spot lights add greatly to the appearance and do not cost a great deal, nor does a tail or a dash light; but the "juice" to light them is something else again. A secondhand 6-volt storage battery will serve the purpose. The battery can be installed in front of the dash, below the steering post.

Now that your coaster is completed in a workmanlike manner, take the time to paint it well. The one illustrated is very effective with orange wheels, dark green running gear and radiator band, and light lettuce-green body. The numeral is black, and on the other side there are four exhaust ports painted black. The inside of the seat back and the seat bottom are bright vermilion. The entire coaster was given two coats, followed, when dry, by a coat of spar varnish.

Note that the gas tank is not only for appearance; it is to provide any accommodating "pusher" with something to push against, thus protecting the back of the seat.

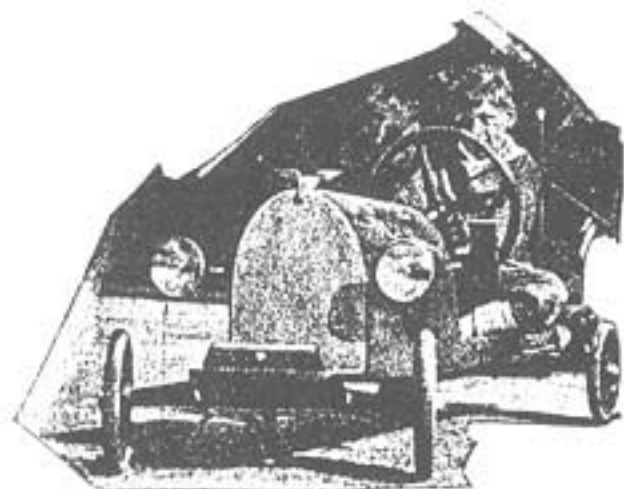


FIG. 48.—Inexpensive spot lights supplied with current from a second-hand storage battery are used as headlights, and the radiator cap is also a standard accessory. A regular steering wheel is used.

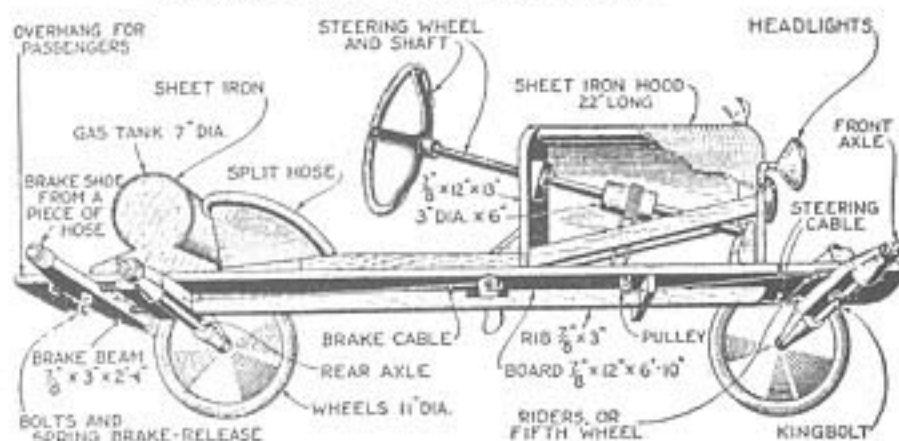


FIG. 49.—Side view of the coaster. To make the brake construction clearer, the pedal has been shown as if it were at the left instead of the right side.

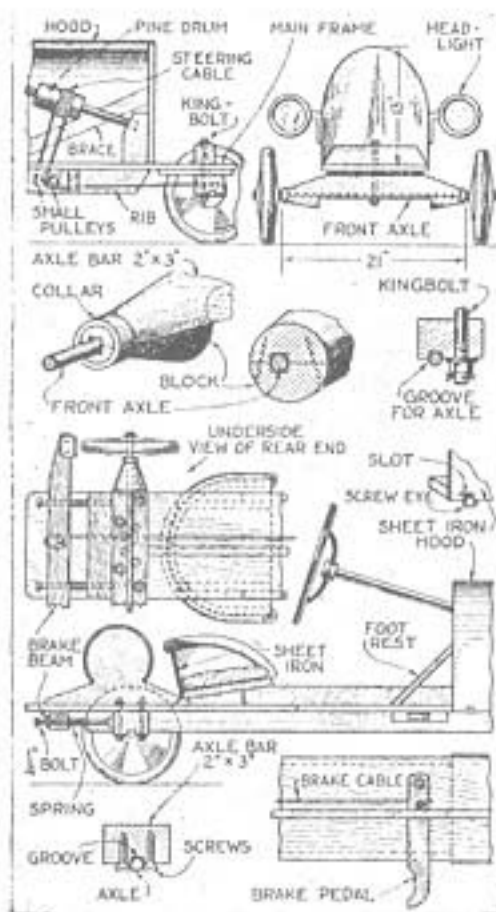


FIG. 50.—How front and rear axles, braking device, imitation gas tank, and other parts are made.

AIR MAIL TOY

Compared with the fun to be had with the auto-plane illustrated in Figs. 51 to 54, the actual cost of the original model was very small—two dollars for wheels, sixty cents for iron, and not over one dollar for all other materials, including lumber, bolts, screws, and paint.

The body was made from a white pine board 1 by 12 in. by 3 ft. 6 in., cut as shown in Fig. 53. A 1/2-in. hole for the steering rod was bored through at the angle indicated.

The two wings, seat and rudder were made from packing case lumber. The wings are 3/8 by 7 by 12 in., rounded on the outside edges. The seat is 5/8 by 7 1/2 by 12 in., edged with a piece of gal-



FIG. 51.—Not only does the propeller turn, but the wings vibrate rapidly as the boy "flies."

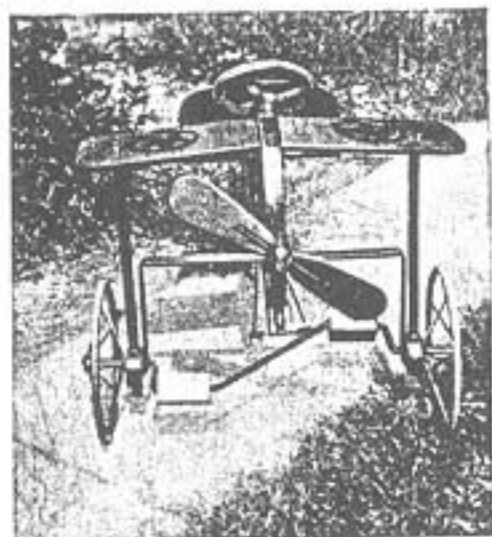


FIG. 52.—Front view. The propeller blades are wedged into the hub with half-round sticks of wood.

vanized tin 4 by 22½ in., which was beaded over wire and the corners rounded down to the front of the seat for neatness.

Wire spoke wheels, two 12 in. in diameter and one 10 in., all with ½-in. holes for the axles, were obtained. The driving axle was made from ⅞ in. round iron, formed cold in the bench vise. Threads were not run on any parts, but cotter pins and washers were used where necessary.

The two brackets that support the driving axle were made from ¼ by 1 in. strap iron, bent cold; each was drilled at one end to receive the ⅞-in. axle. The brackets were bolted to the body (see Figs. 52 and 53).

Each wing was attached with two small hinges so that it could be operated vertically by means of an eccentric attached to the axle by a set screw. The eccentrics (Fig. 54) were made from two 1 by 3 by 3 in. hardwood blocks turned on the shaft of a small motor. A ¾-in. recess was cut in the edge of each block, leaving a ⅛-in. collar on both sides. A connecting ring was bent from ⅛ by ¾ in. strap iron to fit in the recess of each eccentric. The strap iron was extended up to the wings and attached with a loose coupling. The mechanism depresses the wings about 3 in. with each

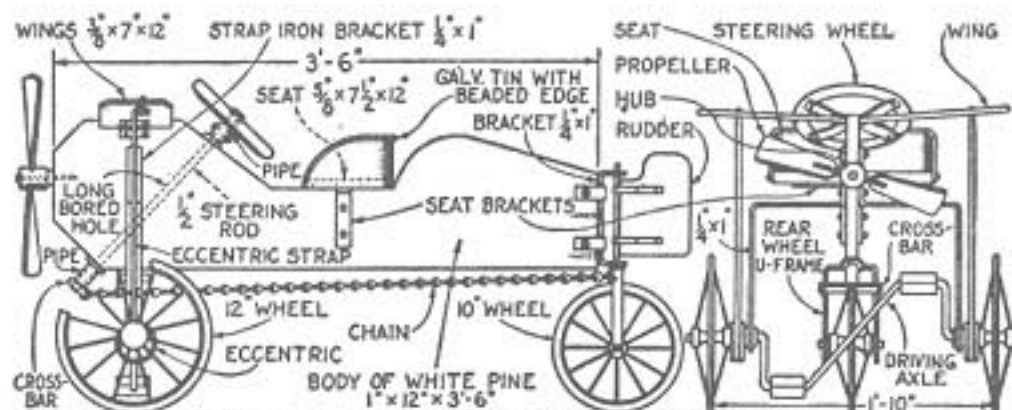


FIG. 53.—Side and front views of the auto-plane with suitable dimensions; these could be changed, however, to suit the size of the rider, and the wings could be stationary.

revolution of the wheels (Fig. 51).

The foot pedals (Fig. 54) were made from two blocks 2 by 2 by 3 in., drilled ½ in. lengthwise and split. The halves were then screwed together over the axle.

The rear wheel bracket was made of ¼ by 1 in. strap iron, drilled ⅞ in. at the lower end and ⅝ in. at the upper end. The bracket was attached to the body by two straps, bolted through (Fig. 53). Two screws were driven in lengthwise of the body to prevent the bracket from sliding up. A ⅞-in. rod was run through the bracket to support the rear wheel. This rod was filed ⅝ in. round at the upper end and filed square at the lower end to fit the square hole in top of the inverted U-axle support. The rod was riveted solidly to the support.

The steering wheel (Fig. 54) was made from an 8-in. square of ⅞-in. birch. A ½-in. hole was drilled in the block, which was slipped over the shaft of a small motor and turned to 7½ in. diameter with a wood chisel, rasp, and sandpaper. The inner edge was turned with a ½-in. chisel part way; then the block was reversed on the motor shaft and cut until the ring slipped off.

The spider was cut from an old Ford steering wheel, obtained from a junk yard for ten cents. The ends of the spider arms were drilled and countersunk to fit the back of the wooden rim. A bushing 2½ in. long of gas pipe was forced through the hole in the steering wheel spider and attached to the steering rod with a stove bolt. Another piece of pipe was used on the lower end of the steering rod as a spacer to the strap iron crosspiece. The lower end of the rod was squared and riveted to the crosspiece. Two lengths of furnace chains were attached to the crosspiece, crossed under the body, and fastened to the rear wheel U-support with two key rings.

The propeller blades were made from two strips of white pine ⅜ by 3 by 8 in., with a ½-in. shank or tenon, which was inserted in the hub and wedged with two pieces of split dowel rod. The hub itself was turned from a 2½ by 2½ by 3 in. block of hardwood.

The body, wings and rudder were painted with dark red, and the ironwork

and seat with black brushing lacquer. The tops of the wings were decorated with a 5-in. black circle with a black star in the center.

One warning might be added: Fasten only one front wheel to the axle, or it will be impossible to turn in a small radius. Wheels may be purchased in pairs, one with a round and the other with a squared hole; otherwise a cotter pin or other means must be used to fasten one wheel to the axle.

WOODEN SEESAW

The seesaw shown in Figs. 55 and 56 requires only six pieces of wood and can be constructed in a comparatively short time. It consists, roughly speaking, of a 10-in. board mounted on a pair of side members, which constitute the rockers. These are set out at an angle, or flared, to give additional stability. The ends of the boards are rounded into seat form, while a notch on either side for the legs or knees and a handle at each end give the children using it adequate means of holding on.

The long board must be selected with care. It should be straight grained, perfectly flat, well dried, and free from knots or holes. That used in the original toy was a trifle less than 10 in. wide and when the edges were planed was but 9¾ in. However, any width up to 12 in. and down to 8 in. could be used. This board happened to be 78 in. long. Any length from 75 to 80 could be used, and by altering the radius of the rockers to suit, even longer or shorter boards would serve

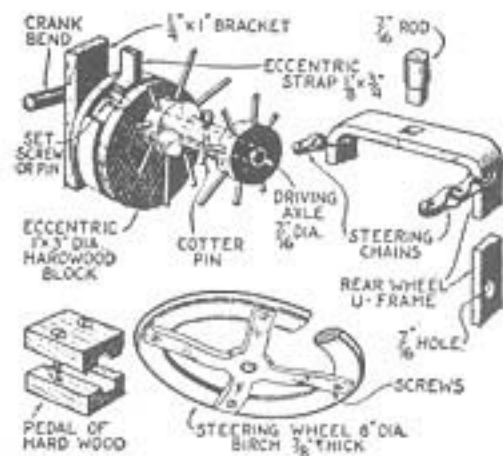
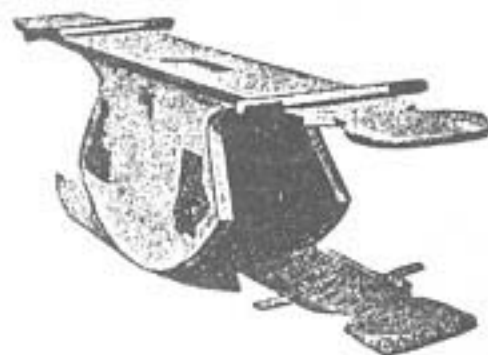


FIG. 54.—How to make the wing eccentrics, pedals, steering wheel, and rear U-frame.



the same purpose just as successfully.

The seesaw will take small children's feet about 10 in. off the ground and that is about as high as most small children

care to go, so it represents a fair average and a most useful size.

The side members or rockers were cut from two heavy boards of $1\frac{1}{2}$ -in. lumber, planed on both sides. These were 18 by 36 in. originally. They were marked with the aid of a cardboard pattern and cut to the correct shape. The angle at which they are set was obtained by planing off one edge of the upper surface before the top board was attached. These parts were put together very rigidly with large nails, except at the extreme ends, where long, slender screws were used.

When the rockers had been attached, a block made from a piece of 2 by 10 in. rough lumber was inserted as near the bottom as practicable and securely nailed. It was made comparatively short, so that in a casual glance at the completed seesaw, one does not see this crosspiece.

The ends of the top board were shaped partly by trial, and the handles were located in a similar manner. The latter

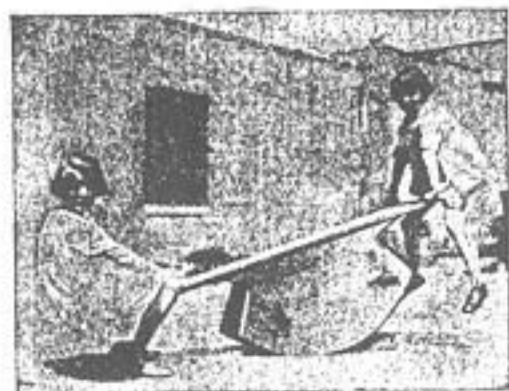


FIG. 55.—Ruggedly constructed of hardwood, this seesaw will last for many years.

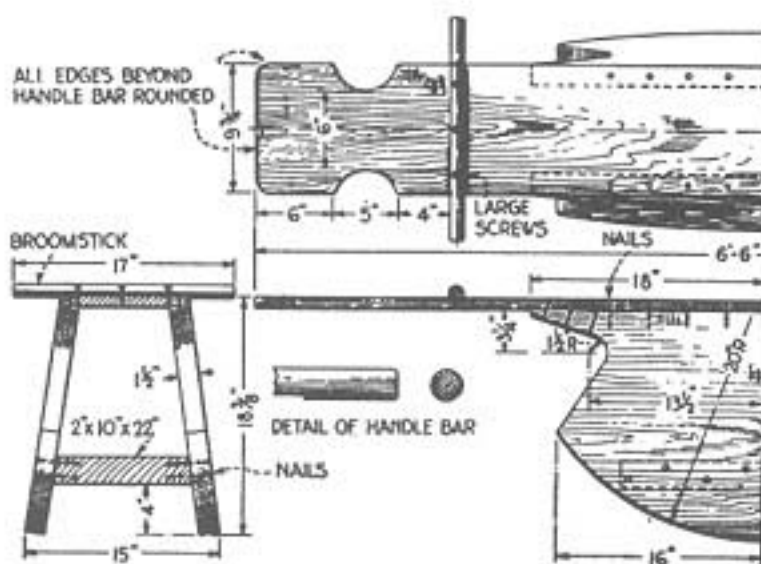


FIG. 56.—Half the top and side views of the seesaw, the end elevation, and a detail of the sturdy broomstick handlebars.

All the upper or under edges with which children possibly could come in contact were rounded carefully with a plane or jack-knife. Be sure there are no splinters to cause injury.

The outfit then was sandpapered and given one coat of flat white paint, followed by a coat of white enamel. After the latter had dried thoroughly, large colored pictures of scenes interesting to children were cut from various magazines and pasted on the sides and top. Then a coat of heavy varnish was applied over all. The pictures show through this, yet they are covered and protected against possible injury.

The whole thing is just heavy enough so that the children cannot move it around without considerable effort. As a result it stays pretty close to the place where it is put, whether on the porch, in the yard, or in the playroom.

SHELVES FOR CHILD'S ROOM

What would delight a small child more than to have for his books and other small belongings a set of hanging shelves which suggest in shape and color a bunny, bird, kitty, clown, or fairy? Such shelves are easy to make and form a unique, colorful decoration in the nursery.

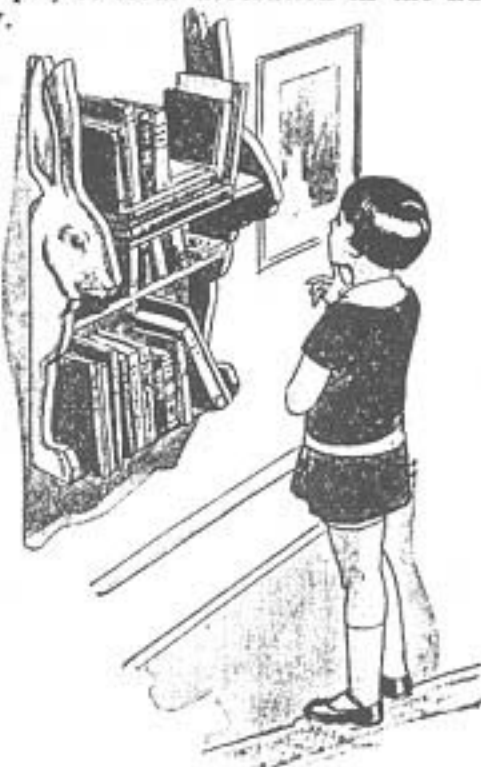


FIG. 57.—"Bunny" shelves. A good color scheme is gray for the body with pink in the center of the ears, red nose and mouth, and black edges.

Five designs for the end pieces are given in Figs. 57 and 58. Other shapes may be devised or copied from toys, and, of course, the size may be whatever the builder chooses.

First make a full size drawing of the chosen design on heavy paper and cut it out for use as a pattern. Trace the outline on soft pine or plywood, either $\frac{1}{2}$ in. or $\frac{3}{8}$ in. thick, and cut it out with

consist of 17-in. lengths of broomstick. They were cut flat on the bottom for the width of the board and held down with stout screws, countersunk so there would be no projections to catch tender young hands. In the center part they were nailed and screwed from below so as to have sufficient strength to resist rough usage. It is always better to err on the side of strength in building toys.

MATERIALS FOR SEESAW

No.	Pcs.	Part	T.	W.	L.
1		Top board	$\frac{3}{4}$	$9\frac{1}{4}$	78
2		Side and rocker planks..	$1\frac{1}{2}$	$17\frac{1}{2}$	36
1		Stiffening block	2	10	22
2		Broomstick handles			17
Stout screws, heavy nails, colored pictures, flat white paint, putty, white enamel, and varnish.					
All dimensions are in inches.					

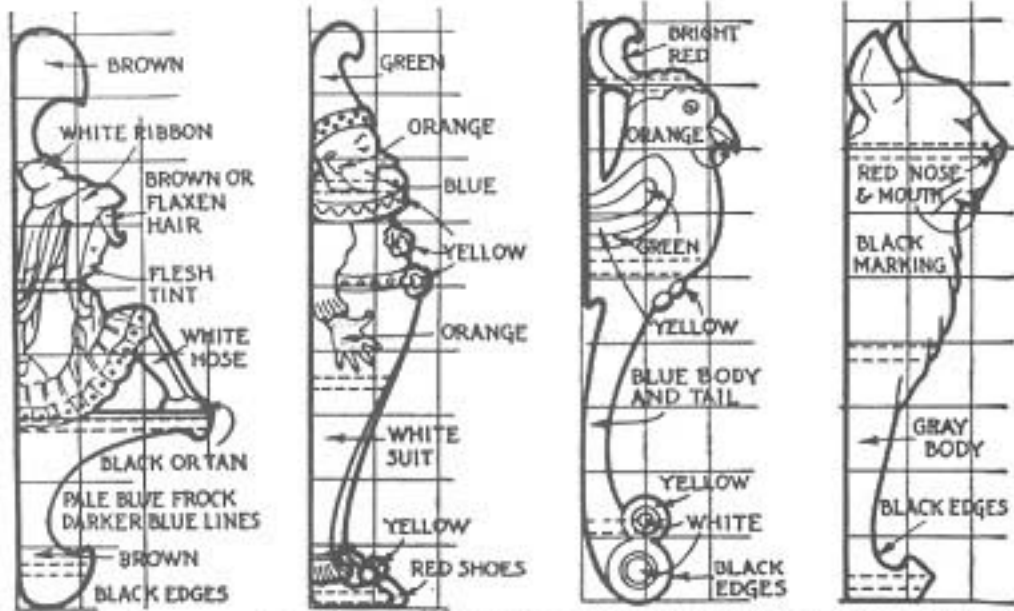


FIG. 58.—Four more attractive end pieces. The squares will aid in enlarging the design to any extent desired. Suitable dimensions are 18, 24, or 30 in. high with shelves 10, 12, or 14 in. long.

an ordinary coping saw, or a power jig saw if one is available. Smooth the edges carefully with sandpaper.

Next lay out the dadoes or grooves which are to receive the shelves and cut them with a chisel. Be sure not to continue the dadoes entirely through to the front edges as they should not show in the finished work. Stop a little back of the front edges and make the shelves exactly as wide as the grooves are long. A quicker but not so workmanlike a job can be done by omitting the grooves and simply nailing shelves in place.

Perhaps the best finish for the shelves is the new brushing lacquer, which can be obtained in many brilliant colors. Suitable color schemes are suggested in the drawings below.

To hang the shelves make two thin metal hangers about $\frac{1}{2}$ by $1\frac{3}{4}$ in. These are screwed to back edges of the end pieces at top and engage round head screws or small hooks in wall.

CHILD'S CHAIR

As a project for either the home workshop or the school woodworking shop, the child's chair illustrated in Figs. 59, 60, and 61 is at once useful and instructive. A set of four forms a fine gift for little sister to use with her table for tea parties. It can be worked as an individual problem in the manual training shop, or developed on a productive basis in an industrial shop where machinery can be used for much of the work.

The original model was developed in a Pittsburgh continuation school, and many of the chairs were made to supply seats for the primary rooms of the different public schools. Some expense was saved by using lumber salvaged from large packing boxes supplied by near-by mercantile establishments. That



FIG. 59.—Its strong construction makes this chair especially suited for the hard usage which children give.

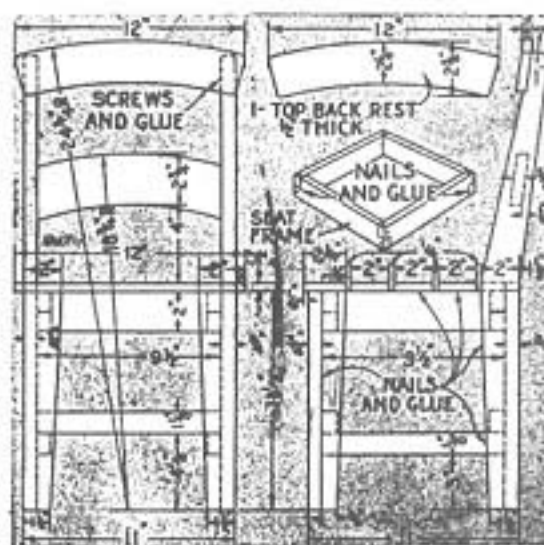


FIG. 60.—The joints are held with glue and screws or nails. Note method of joining the seat frame.

may be a suggestion to the boy having a home workshop. He might ask a hardware dealer or a dry goods merchant

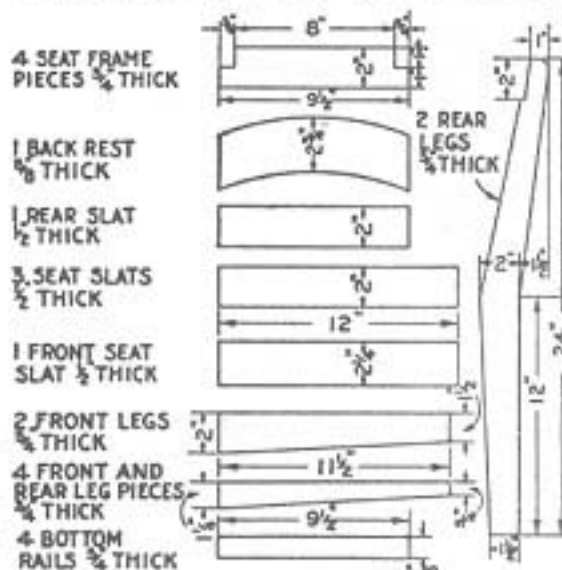


FIG. 61.—If one piece is laid out accurately, it can be used as a template for the others of the same size.

for a box that would be suitable for making the chair.

Since many of the parts are duplicates of others, it is necessary to lay out only one piece of each set accurately; the finished piece will serve as a template for the others. When the chairs are to be made on the production basis, the templates may be made from sheet metal.

MODEL VILLAGE MADE FROM BLOCKS

Every boy at some time or other has held a block of wood in his hand and asked himself: "Now what can I make out of this old chunk of wood?"

Why, hundreds of things!

For example, a whole miniature village (Figs. 65 and 66) can be cut easily from blocks of white pine. Small auxiliary parts can be made of bits of wood

or heavy cardboard and glued on. The completed buildings can be painted in various colors and given red or green roofs. Then they can be placed in a suitable setting with streets, trees, shrubbery, and accessories.

Line off each block in 1-in. squares. Mark with heavier pencil lines just where you intend to begin cutting, and then use a fine saw and a knife to work out the finished forms. In the absence of a fine-tooth wood saw, a hack saw blade can be used, and a keen pocket-knife will reach the places where the saw cannot reach.



FIG. 65.—From soft pine blocks, a boy can easily cut picturesque buildings.

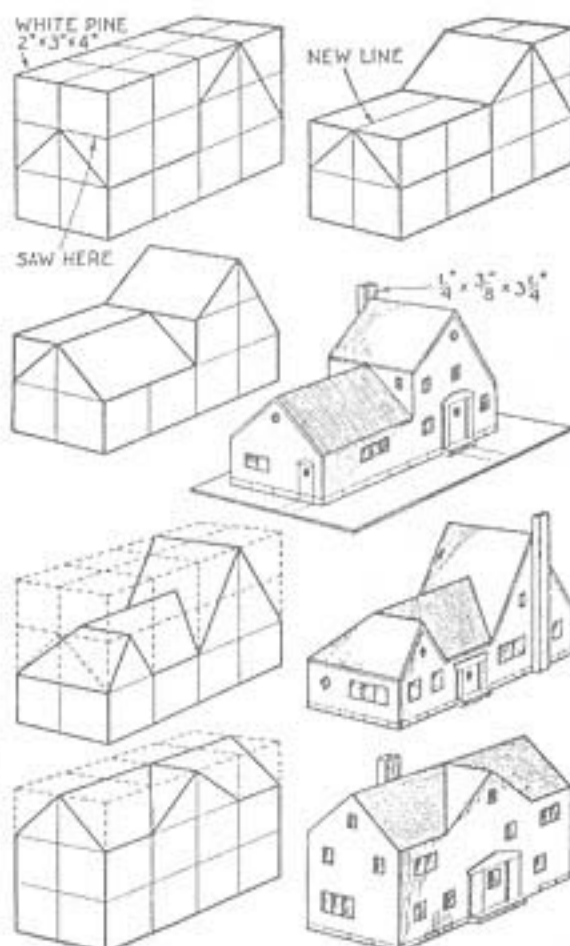


FIG. 66.—Steps in blocking out and shaping the houses. Much depends upon painting them neatly.



FIG. 11.—This doll's house is a realistic model of a fine Colonial home.

COLONIAL DOLL'S HOUSE

No gift is apt to delight a small girl quite so much as a really fine doll's house. To her it is a fairy home where her doll children can live and play. She can devise new furnishings, redecorate the rooms, and sweep, dust, wash and cook to her heart's content.

And after all, isn't that the secret of a satisfying toy? It must allow the child to do something genuinely constructive and stimulate her imagination and ingenuity; at the same time, it should convey a sense of grown-up reality. A doll's house does all this, especially if it is as complete and realistic a model of a house as the one illustrated on this page.

At first glance the doll's house in Fig. 11, which is based upon one of the most popular Colonial designs, may appear to be complicated in its construction, but when examined closely and studied well it will be found relatively simple for any handy man or boy to build in spare moments in his home workshop. Only household tools are needed and no high degree of skill or previous experience is called for.

The first thing to do is to study the drawings (Figs. 12 to 16) until a clear understanding of the method of construction is obtained; the next is to examine the list of parts.

The best material to use is either plywood or wallboard, because they do not readily warp or split. The thickness for all the major parts of the house should be preferably $\frac{1}{2}$ in., although $\frac{3}{8}$ -in. stock can be used if the other cannot be obtained. Of course, any difference of thickness will make a slight variation in the length of some of the parts. As many of these materials come in

regular sizes of $\frac{1}{4}$ in., they may be glued together and used double thickness to make $\frac{1}{2}$ in.

Veneered stock such as is found in

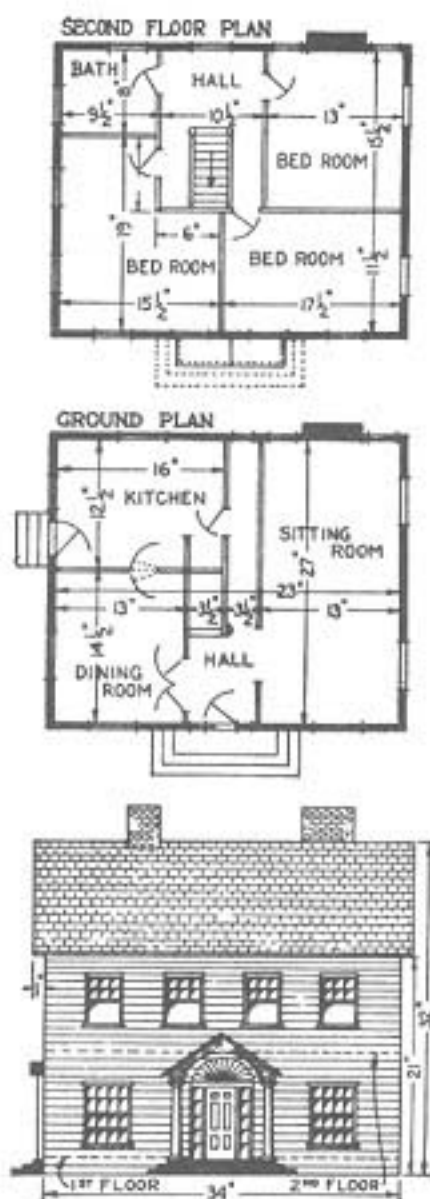


FIG. 12.—How closely the model resembles a real house is shown by the plans and front view.

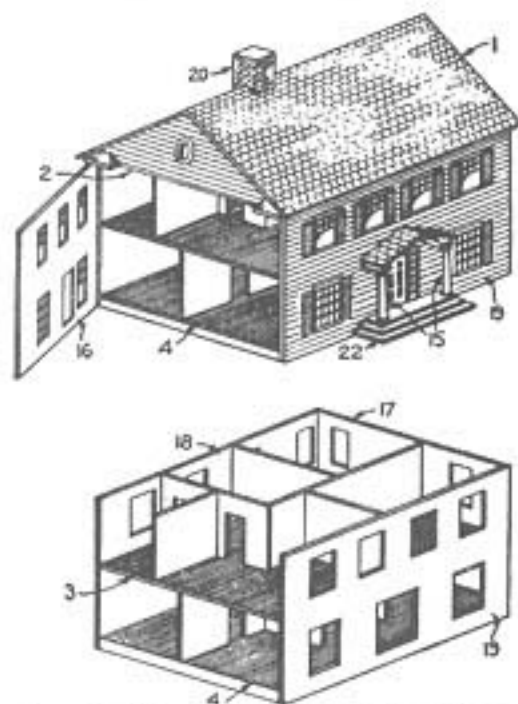


FIG. 13.—The floors, walls, and partitions before and after the roof and trimmings are added.

some packing boxes may be made use of in the construction of the house. This usually is $\frac{3}{8}$ in. thick and may be had very cheaply.

The drawings are for a house that is just one twelfth the size of a real house, and all of the furniture and parts are planned on this scale. A smaller house may be made by reducing the dimensions proportionately.

In Figs. 13 and 14 is shown the method of construction. With the two floor boards, Nos. 3 and 4, squared and sandpapered and the upper ceiling board No. 2 in shape, the position of the walls should be marked off carefully, using the plans in Fig. 12 as guide. Nos. 3 and 4 are each $\frac{1}{2}$ by 27 by 33 in., while No. 2 is $\frac{1}{2}$ by 29 $\frac{1}{2}$ by 34 in. The main floor board is reinforced with the edges with a 1 by 2 in. strip marked 4A in Fig. 14; this extends all the way around the edge and across the middle.

As the second floor board (No. 3) serves as floor and ceiling, it is sandpapered on both sides.

The rooms will be so small when the house is assembled that it will be next to impossible to do much nailing or other work within them. For this reason it will be best to do all the fitting of doors, bases, casing, stairs, and the like before the house is completed. The three sections shown in Fig. 14 should each be assembled as separate units. Do all wall painting or decorating and floor polishing while the sections are still open.

Next, the outside walls should be made up. The door and window openings should be marked out accurately on both sides of the board and cut out with an ordinary coping saw or keyhole saw.

For casing and finishing the doors and windows see Fig. 16. The casings may

be made of $\frac{1}{8}$ -in. wood. The cheap yardsticks that some firms use as advertising mediums, if planed smooth and ripped through the center, are just the thing for the purpose. If these cannot be found, heavy cardboard or berry crates will serve quite well. If the casings are placed even with the edge of the openings, frames will not be needed. The baseboards should be $\frac{3}{4}$ in. wide and the same thickness as the casings.

The stairs (Figs. 15 and 18) will be found to be the most difficult part of the construction. It is hardly possible to show their construction fully enough, but the details can be supplemented by the reader's observation and ingenuity. The stair steps may be glued to a thin board, each step being a solid block. Another plan would be to cut the steps from a solid block. Only the six lower steps are exposed to view, the other seven being hidden between walls Nos. 12 and 14. The stair well in the second floor is 3 by 7¼ in. and cut so that it is directly between walls 12 and 14.

The balustrades are made of match sticks glued between a top and bottom rail. The newel post may be a clothespin or a round penholder.

When all of the small details are in place and the walls tinted, the three sections shown in Fig. 14 may be assembled, using $\frac{3}{4}$ -in. flat-head screws. The front and back should be screwed in place at this time and the two ends and roof hinged. One hinge on the roof will have to have an extension soldered to it to allow it to open out to the line of the chimney.

It is left to the reader as to what kind of roof he will use (see Fig. 17). Small

shingles may be nailed or glued in place; they look well but take a great deal of time to construct. The divisions between

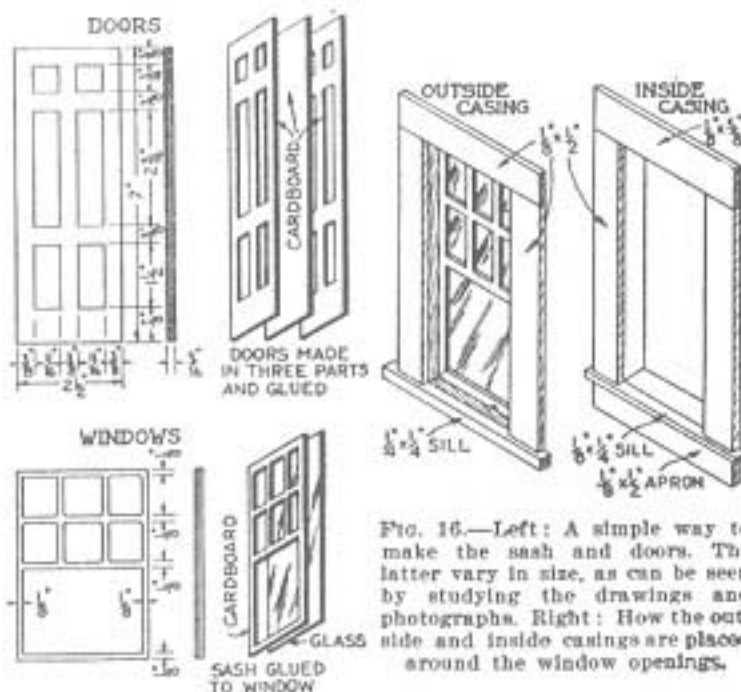


FIG. 16.—Left: A simple way to make the sash and doors. The latter vary in size, as can be seen by studying the drawings and photographs. Right: How the outside and inside casings are placed around the window openings.

the shingles may be represented by making grooves with the point of a nail set or a chisel. The same method may be used for lining the siding boards.

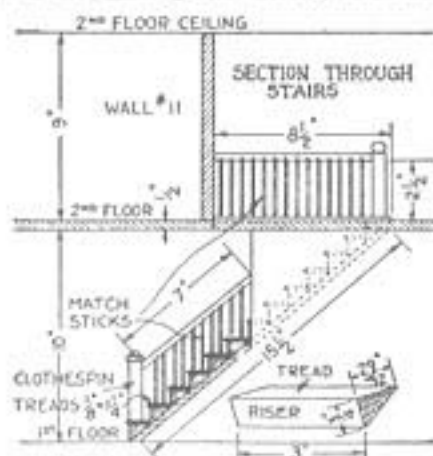


FIG. 15.—The stairs are made by gluing triangular steps to a thin board and adding tiny treads.

The chimneys are made of solid blocks of wood and the bricks carved with a chisel or sharp knife.

MATERIALS FOR DOLL'S HOUSE

No.	Item and Remarks	T.	W.	L.	Rq.
1	Roof	$\frac{1}{2}$	19	37	2
2	Second floor ceiling.	$\frac{1}{2}$	29 $\frac{1}{2}$	34	1
3	" " "	$\frac{1}{2}$	27	33	1
4	First " "	$\frac{1}{2}$	27	33	1
4A	" " base ..	1	2	34	4
5	Gable ends	$\frac{3}{4}$	29 $\frac{1}{2}$	10	2
6	Wall	$\frac{1}{2}$	9	23	1
7	"	$\frac{1}{2}$	9	15 $\frac{1}{4}$	1
8	"	$\frac{1}{2}$	9	15 $\frac{1}{4}$	1
9	"	$\frac{1}{2}$	9	9 $\frac{1}{4}$	1
10	"	$\frac{1}{2}$	9	11 $\frac{1}{4}$	1
11	"	$\frac{1}{2}$	10	27	1
12	"	$\frac{1}{2}$	10	18 $\frac{1}{4}$	1
13	"	$\frac{1}{2}$	10	16 $\frac{1}{4}$	1
14	"	$\frac{1}{2}$	10	20 $\frac{1}{4}$	1
15	Columns 1 in. in diameter at large end 1				
16	Left end	$\frac{1}{2}$	21	27	1
17	Right "	$\frac{1}{2}$	21	27	1
18	Back	$\frac{1}{2}$	21	34	1
19	Front	$\frac{1}{2}$	21	34	1
20	Small chimney	3	3	4	1
21	Large " (proper) 1	6	21		1
21A	" " (top) ... 2	5	15		1
22	Fireplace	$\frac{1}{2}$	6 $\frac{1}{2}$	4	1
23	Front porch roof....	$\frac{1}{4}$	6 $\frac{1}{2}$	2 $\frac{3}{4}$	2
24	Back " "	$\frac{1}{4}$	2 $\frac{3}{4}$	1 $\frac{1}{2}$	2
25	Return roofs at ends 1 $\frac{1}{2}$	1 $\frac{1}{2}$	4	4	4
26	Front porch steps....	1 $\frac{1}{2}$	4 $\frac{1}{2}$	14	1
27	Back " " ... 1 $\frac{1}{2}$	3 $\frac{1}{4}$	5	1	1
28	Front porch arch....	2 $\frac{1}{4}$	10	4	1
29	Back " frame ..	$\frac{1}{2}$	3 $\frac{1}{2}$	9 $\frac{1}{4}$	1
30	Stair horse	$\frac{1}{4}$	3	15 $\frac{1}{2}$	1
31	Steps—triangular ...	$\frac{3}{4}$	2 $\frac{1}{2}$	3	13
32	" —treads	$\frac{3}{4}$	1 $\frac{1}{4}$	3	13
33	Stair posts (clothes pins)				1
34	Stair posts (clothes pins)				1
35	Stair rails	$\frac{3}{16}$	$\frac{1}{4}$	8 $\frac{1}{2}$	3
36	" balustrade (of match sticks)				30
	Doors and windows made like drawing to fit.				
	Casings $\frac{1}{8}$ by $\frac{1}{2}$ in. wood or cardboard.				
	Small brass hinges, 3 pairs.				
	All dimensions are in inches. All material wood except where otherwise specified.				

The construction of the front entrance is shown in Fig. 12. The arch is shaped with the coping saw; the roof boards are

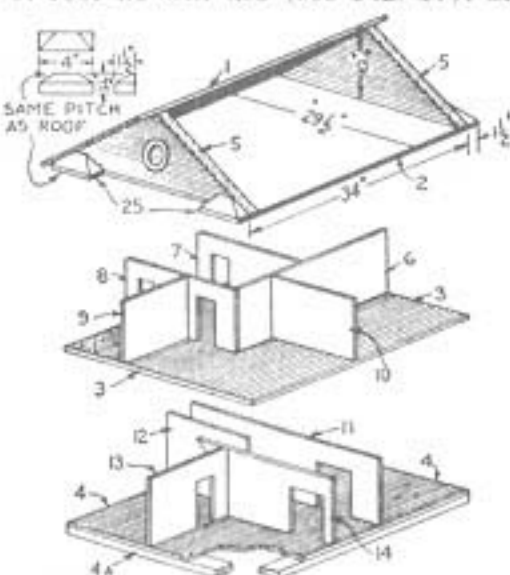


FIG. 14—The house is made in three parts. The small fittings are added before putting the sections together.

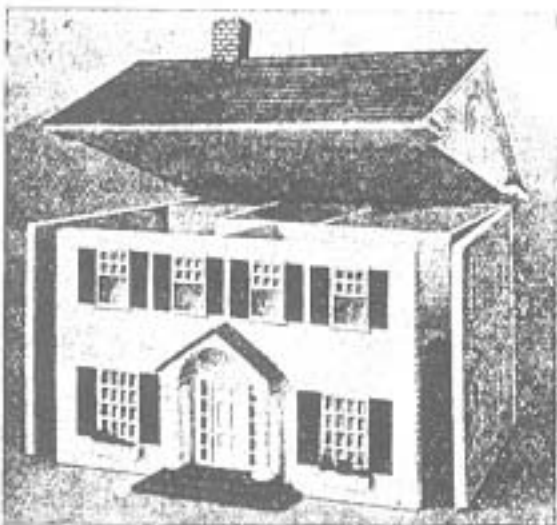
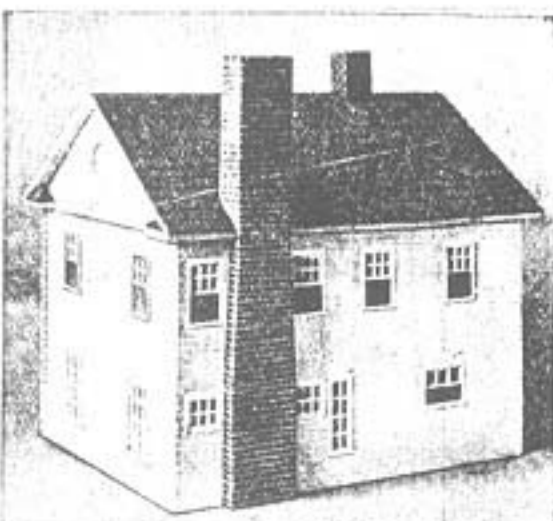


FIG. 17.—Left: Front view of the house showing how the roof section and the side walls are hinged to allow ready access to both upstairs and downstairs rooms. Right: A view of the house as seen from the rear.



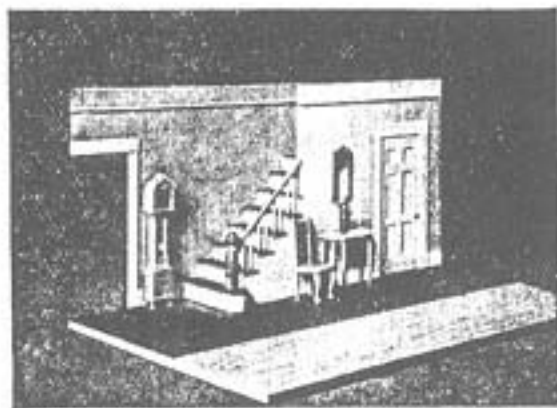


FIG. 18.—How the stairs are built and the hall is furnished with a miniature clock, table, chair, and mirror.

made to match the main roof. The columns may be turned on a lathe or made square, or a small bracket may be used to support the sides of the roof.

The steps in front and at the side are merely three $\frac{1}{2}$ -in. sections fastened together and carved like the chimneys. The sunburst design over the door may be carved with a knife or carving chisel.

Making up the window sash is more tedious than difficult. A good sharp knife will be the greatest asset. The method is shown in Fig. 16. Tough and quite heavy cardboard should be used. When the sash are cut, they are glued to a piece of glass or celluloid of the same width and length. Each sash should be made to fit its particular opening. The construction of the door also is shown in Fig. 16.

Small green shutters serve to brighten the appearance of the house and may be made easily. A piece of very thin wood with a simple design grooved in the outside face is all that is needed for each shutter. These pieces are nailed to the side of the windows.

Small window boxes—blocks with holes for the flowers—may be used under the windows. Pieces of sponges, colored like plants and shrubs and glued on top of the boxes, are quite effective.

Careful painting adds greatly to the attractiveness of the house; it is one of the most important items. The colors suggested (see Fig. 17) are green for roof and shutters, white for the body and doors and window sash, and red for the steps and chimneys. It is well to give the house two or three coats of paint or brushing lacquer.

The inside woodwork (Fig. 18) should be painted white along with the doors. The floors may be stained or finished with clear varnish. Paper or tint the walls.

Furniture, bath and kitchen fixtures may be obtained ready made at the toy shops, where some substantial and well formed models are to be found. These should be of the proper size to match the house. It is more satisfactory, however, to make the pieces in the home shop.

The porcelain fixtures for the bathroom and kitchen may be shaped or carved from solid wood to resemble as closely as possible the real pieces. These models are covered with a heavy layer of gesso made of glue and whiting and painted with white enamel to give them the resemblance of porcelain.

BIRDS AND ANIMALS

Toy making is not difficult. It may be done quite as well by women and girls as by men and boys. In fact, very few of those who have never attempted the work realize how simple it is to

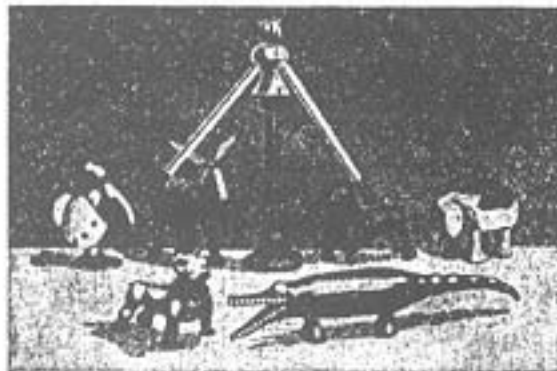


FIG. 21.—Some toys from the collection of F. Clarke Hughes, who is a specialist in their design and construction.

construct attractive toys—toys that will give keen and lasting delight to the children who receive them.

About the only equipment necessary for making many little toys are a coping (fret or bracket) saw, a jackknife, a hammer, and a rule. While other tools are sometimes needed and are always useful, they are not essential. Do not, therefore, let the lack of tools or a bench prevent you from beginning.

Once you have fallen under the fascination of the work and discovered what fun there is in making toys, you will delight in adding new tools to your kit, and in a short time you will have a home workshop equipped for much more ambitious undertakings.

The subject of tools cannot be dismissed without mentioning a lathe. Indeed, for many of the spindle toys so much in vogue these days, a wood turn-

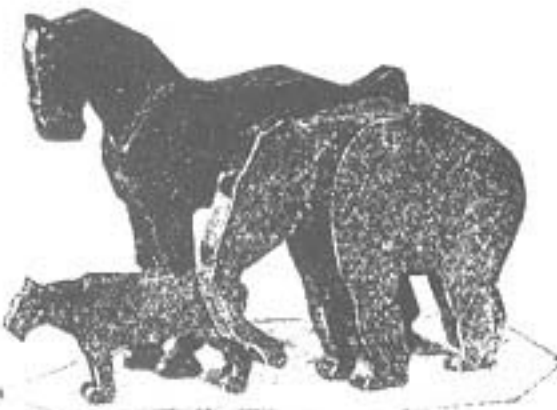


FIG. 22.—Well-designed wooden animal toys are more popular to-day than ever, and making them is great fun.

ing lathe is the thing to use. Those who become thoroughly interested in toy making will want to have a lathe sooner or later, but in the beginning it is usually possible to devise a substitute tool process or change the design of the toy so that turning is not required.

In cutting out practically all of the toys illustrated in Figs. 21 to 26, an ordinary coping saw is sufficient. These saws may be purchased at hardware stores and are among the most inexpensive of tools. A supply of extra coping saw blades should be obtained; they, too, are cheap, so that the breaking of them, which is bound to happen now and then, is a small matter.

The correct method of using a coping saw is illustrated in Fig. 24. Boards as heavy as 1 in. in thickness, if of white pine, basswood or any soft wood, may be sawed quite easily in this way.

In Fig. 26 are shown a number of animal forms that were drawn especially



FIG. 23.—"Cute" may justly be used to describe some of these brilliant and charming little toys.

for wooden toys. These may be enlarged and used as patterns for toys of many types and sizes.

Decide first to what size you wish to enlarge the toy. Draw on a piece of stiff paper or thin cardboard the same number of squares as appear over the outline you intend to copy, but make the squares proportionately larger. In each square draw whatever appears on the corresponding but much smaller square in Fig. 26, so that you will obtain an exact enlargement of the original drawing. The elephant, for instance, is $7\frac{1}{2}$ in. long over all and $5\frac{1}{2}$ in. high; the pelican is 7 in. long and $5\frac{1}{2}$ in. high; the puppy dog is $4\frac{1}{2}$ by 5 in., and the others are of corresponding proportions. There is enough variety to keep you busy for weeks.

From the full size drawings you can transfer whatever designs you wish on the wood by means of typewriter carbon paper. Another method, which is quicker if you intend to make a quantity of the toys or have the children help with the work, is to paste the various designs on bristol board or tough, thin cardboard and then cut them out so that they can

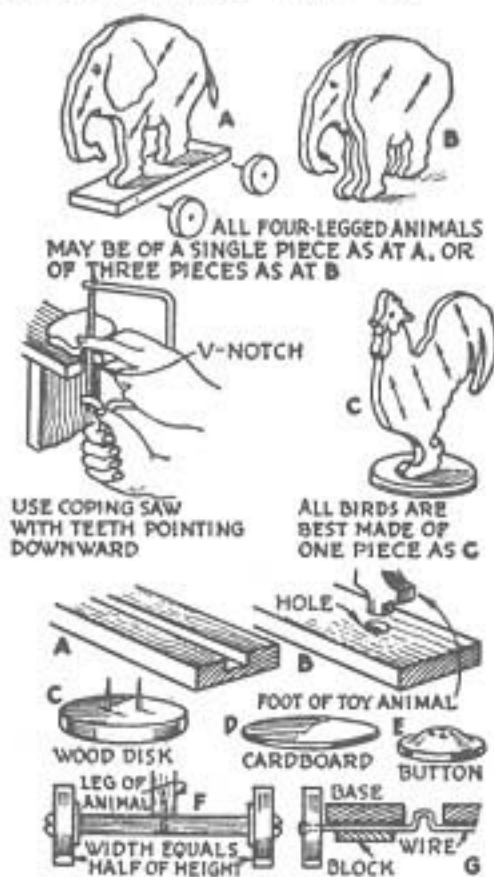
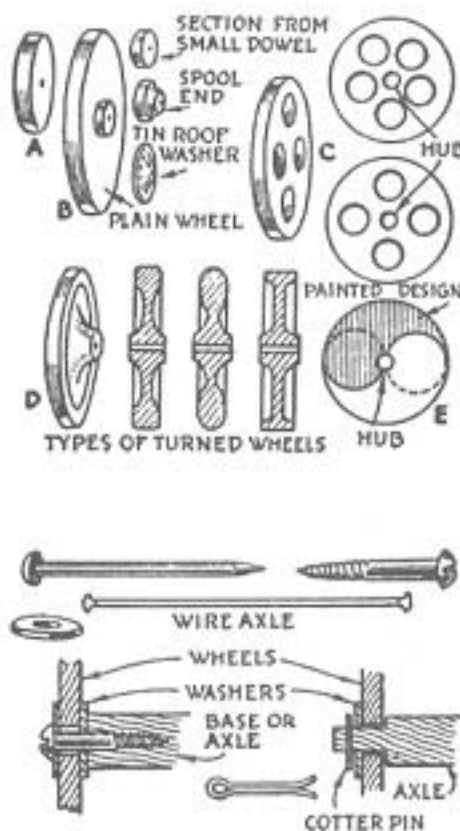


FIG. 24.—Left: One- and three-piece toys and several types of bases; how to cut the forms with a coping saw. Right: Wheel construction at a glance; various hubs, decorations, and methods of mounting.



be used as templates to trace around.

Attention is called to the character of most of these forms, with their simple lines and large feet. If these forms had not been changed in this way the smaller parts would split when cut from wood. Tails in most cases should be removed entirely when sawing and leather or twine substituted.

It will be noticed also that all of the illustrations of birds in Fig. 26 show only one leg; and of the animals, only the cow has all four legs. This simplification, if the toys are cut from one piece of wood, makes the work easier and the result more satisfactory from the standpoint of durability.

You are not limited to these designs. Many pictures of animals may be found in books, magazines and newspapers, and these may be made adaptable to wooden toys if simplified in the light of the designs shown.

If a toy is to be cut from plain boards, the grain of the wood must be considered and made to run in the direction best serving to strengthen the weaker parts. The different drawings in Fig. 26 have arrows to indicate the direction in which the grain of the wood should run. If three-ply wood is used the grain usually can be ignored.

What thickness of wood to select depends upon the size of the toy, the form of construction, and, to a lesser degree, upon the kind of wood. Three-ply parts can be thinner than those of solid wood.

An elephant made the size shown should be $\frac{3}{4}$ in. thick if a single piece,

and $\frac{5}{16}$ or $\frac{3}{8}$ in. thick if in three parts. The cow, cat and donkey should be $\frac{1}{2}$ in. thick if single and $\frac{5}{16}$ in. if in three pieces. The birds and fowl may all be $\frac{1}{2}$ in. thick.

The duck can be made into an especially attractive toy if cut from $\frac{1}{4}$ in. thick stock with the head separate and loosely doweled in place so that it will turn. The puppy looks best if $\frac{3}{4}$ in. thick.

After the toy has been cut to shape and smoothed with a bit of sandpaper, the kind and style of base should be carefully considered, because the base has much to do with the general attractiveness of the finished article. Each in-

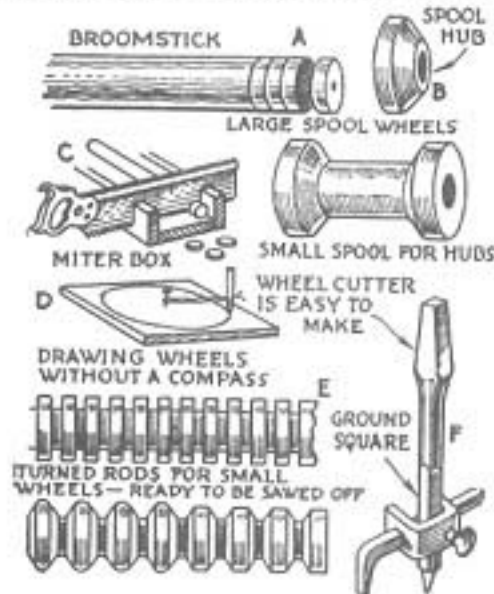


FIG. 25.—Left: Broomsticks and spools as used for wheels; methods of turning wheels; a wheel cutter. Right: Toys weighted so as always to remain upright; "wobble" toys with jointed bodies.

dividual toy seems to call for a special type of base and the form should be studied with this in mind. Some toys look best on a round base, others need a square base.

If wheels are to be used on the base, the size of the wheels should be considered in relation to the width of the base. As a general rule, the width of the base should equal about one half the height of the toy.

In Fig. 24 are shown a number of bases. A and B are removable. In the case of smaller animals for a Noah's Ark and other collective groups, a small cardboard disk glued to the foot is sufficient.

Wooden animals may be made up in a single piece, or in three sections nailed together, as in Fig. 24. For birds and fowls either a base is used or wheels with a counterbalance (Fig. 25).

Small wheels may be made from a broomstick or curtain rod as suggested in Fig. 25. A stop block placed in the miter box helps to keep the thickness uniform. Two styles of small turned wheels are shown.

In finding the center and drilling the holes in all of the wheels, care must be observed, or they will be one-sided. A jig with a fixed center can be devised to aid in drilling these centers.

For drawing the larger wheels use a compass or pair of dividers or the method shown in Fig. 25.

If a washer cutter, such as used by steam fitters for cutting gaskets, is to be had, a very good set of wheels may be cut out, provided the wood does not exceed $\frac{1}{2}$ in. in thickness. A satisfactory wheel or washer cutter may indeed be improvised as shown in Fig. 25. The shank is made from an old auger bit.

The larger wheels may be varied in appearance by using different hubs with a plain wheel, as shown in Fig. 24. Tin roofing washers used for hubs give neat-

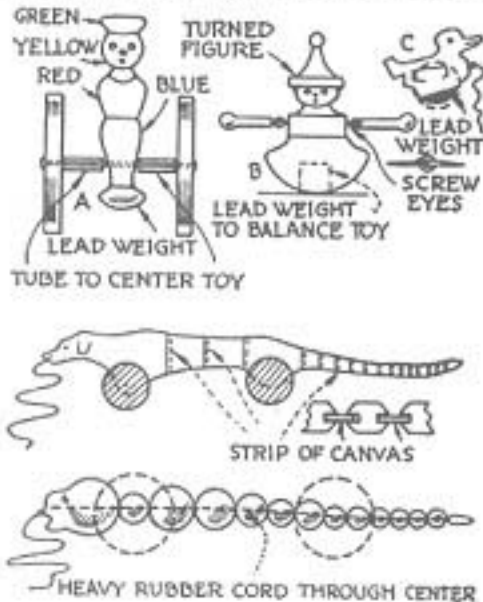




FIG. 26.—Outlines of bird and animal toys on squares to facilitate enlarging them.

looking wheels. Again, several holes may be bored through wooden wheels, as indicated, to lighten them. In Fig. 24 is also a painted design that looks well on

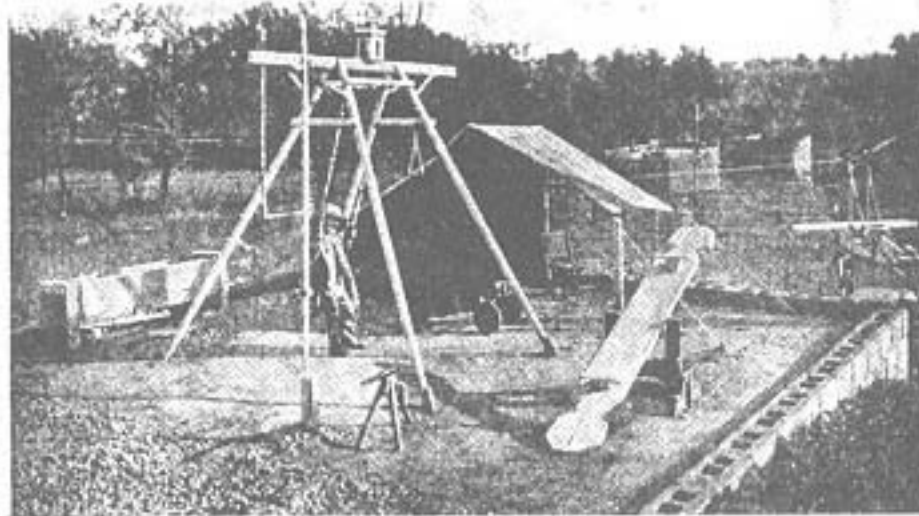


FIG. 27.—A back yard playground. At the right is the airplane, a larger view of which is shown in FIG. 28. The teeter-totter, swing, and trapeze in the foreground, and the boat tank at the left will provide hours of healthful outdoor amusement for the children.

circus wagons, carts, and the like. Some examples of turned wheels of various designs are shown in the same group of drawings.

Spindles or bearings for the wheels may be of several different types, as shown in the lower left-hand corner of Fig. 24.

Among the newer wooden toys on the market are to be found some precious and attractive little wheel toys that are weighted so they always remain in an upright position. Figure 25 suggests how several of these little novelties are made. Beads sometimes may be used as spacers instead of tubes.

Some of the semimechanical animal toys in the toy shops have one end hinged so that the other can be moved up and down by an eccentric in one of the axles. The principle of the eccentric is indicated in Fig. 24.

The jointed toy made in several sections and arranged to wiggle when it is drawn along is always interesting to the children and quite simple in construction, as shown in Fig. 25.

The main points in successful toy

making are simple lines, solid construction, and clear, bright colors.

For the most of the smaller toys the gloss paints, carriage or auto enamels and colored lacquers have been found most satisfactory. For simple work the three primary colors, bright red, clear, brilliant blue, and yellow, with the addition of black and white, are all that are needed. They may be combined to form all the others. The work should be given a priming coat first, and when this is dry, the colors applied in the order of the lightest first. As a rule it is best to let each color dry before applying the others. Eyes and small lines may be added with the point of a nail or a toothpick or a small pencil brush.

A BACK YARD PLAYGROUND

Any boy or girl would like to come and play in the yard illustrated in Fig. 27. There is nothing difficult in building one like it; indeed, any father or brother can build these toys and apparatus at small cost, with little work on his part.

TOYS AND TOY MAKING

Cassell's Home Encyclopedia
England, 1920

Children find expression in toys from earliest infancy. A rattle or a coral with tinkling bells inspires them with the desire to repeat the pleasant sound. A brilliantly coloured ball excites their admiration. They pass through a stage of surprise at a jack-in-a-box or clockwork animal to curiosity, which, though perhaps indulged in at the expense of the particular toy, is the beginning of knowledge and invention. Imagination is stimulated by the games of make-believe, from a Noah's ark or doll's house to the wonder of things made by hand with carpentering sets and plasticine to a meccano set.

The playing of games of skill with hard-and-fast rules develops a child's character by the discipline of competition within limits, but into

his play with toys he weaves the fancies which are the outcome of his individuality.

For this reason it is a mistake to interfere too much with his choice among his toys. Having had the winding-up of a new tumbling clown explained to him, he may be delighted with its novelty for a while, but when that has worn off he has no further use for it, and turns to play for hours with a grocer's shop, weighing out commodities from bottles and tins on miniature scales, or doing up tiny parcels and falling in gladly with a suggestion that his horse and cart should be a delivery van. The great thing is that he should learn concentration by being absorbed in what he is doing at the time. Boredom lies in going from one toy to another in desultory fashion.

Toys should be put away when playtime is over, and a child should have a special shelf if a cupboard or locker of his own is not possible. If it can be avoided, it is a mistake ruthlessly to sweep away his unfinished creation of bricks or



December 1872

The Night before Christmas.



December 1872

Christmas Morning.

the setting of a farmyard drama, but a warning can be given that time is nearly up, and sometimes a little assistance will help towards the satisfactory completion of an edifice or episode. The care and repair of toys should be taught to children from an early age.

Some children delight in miniature things. They like to collect families of tiny dolls, furniture, and animals. A few low shelves where they can set out these things and leave them undisturbed till the next playtime is a happy arrangement, especially if provided with a curtain on rod and rings. Other children like to impersonate the characters in their games. A toy outfit of a bus conductor may give more pleasure than a mechanical model of a motor bus, even though a sofa with a few dolls on it represents the vehicle to be driven.

Outdoor toys are nearly always fascinating. Hoops, skipping-ropes, secotors, battledore and shuttlecock, sailing boats, balls and dolls' perambulators all have their attractions, but probably none give more joy than the wooden spade, the shrimping net, and the tin pail at the seaside. The garden becomes an absorbing toy. Such gifts as a practical toy gardening set and a wheelbarrow, and a small piece of the garden, usually have a great appeal.

When choosing a toy as a present, especially for a small child, occasionally people make the mistake of giving something which amuses them,

such as a mascot or novelty of the moment, which has no meaning to the little recipient, instead of some simple toy which would really please. Should the present be intended to impress the parents of the child rather than the child himself, it is better to let it take some other form.

Mechanical Toys. Constructional toys in the form of collections of parts afford much entertainment to children of the age to understand them. It is a waste of money to give such sets to a younger child, who will be better pleased with a robust clockwork toy. The constructional set depends for much of its entertainment and educational value upon the appeal it makes to the imagination and ingenuity of the owner, who can combine and re-combine the parts in a variety of ways. The parents can initiate the work, and assist, but the youngster should be left to solve his own problems as far as possible.

The common tinplate track as supplied with train sets is usually neither strong nor durable, and it is well worth while to purchase a good set of rails from one of the reliable firms which specialize in these

goods.

A word of advice may be given here about electric sets.

An accumulator is the best

means of supplying the current to the conductor rails. It can be placed on a shelf out of harm's way, the leads being taken down to floor level and ending in a plug fastened to the skirting. The leads should be secured to the wall in some way, and also to the shelf, so that the battery cannot be dislodged by a pull on the wires. Another method is to make a simple wooden box to hold the accumulator, the lid being secured by a small lock, and the box being screwed to the floor in a corner of the room. In this case also the leads can be taken to a plug on floor or skirting. Train sets can be obtained for connecting to the electric light mains, but these are not suitable for children without supervision.

There is a third method of running an electric train, in which a small battery carried in the engine or tender supplies the current. The battery has to be replaced by a new one at frequent intervals, of course, but this is a simple method, and no conductor rails are needed on the track. The above remarks apply to the smaller or toy train sets.

Mending Toys. The cheaper clockwork toys do not usually admit of repair, and even in the case of the better made ones the gears and spring wear out or lose resilience, as the case may be, after a period of strenuous service.

Glue is the proper adhesive for wooden toys, but in addition it is often advisable to drill a hole and insert a wood screw across the joint of a

fractured part. In fitting screws the preliminary drilling for the screw should not be forgotten, as toys are generally made of the cheapest kind of wood.

The toy maker frequently drives a big nail or screw into the end of a wooden rail and makes the nail the axle of a wheel supporting the whole weight of the toy. Such fixings in end grains are never satisfactory. A cure may be effected by crossing the screw with a wooden plug, or by fitting an all-metal axle such as is used in a perambulator. Wooden wheels should be supplied with axle bearings of (bushed with) short pieces of brass tube.

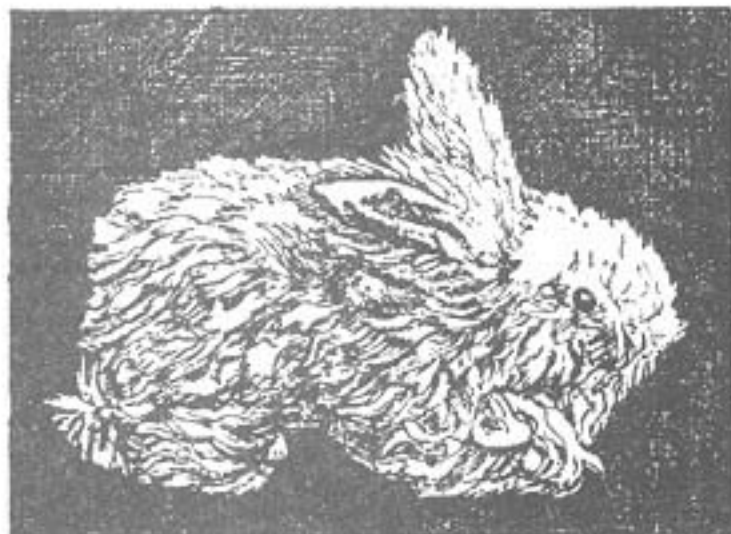
Soft Toys. Instructions are given in the article on Dolls for making a rag doll, and other soft toys are dealt with in the article on Knitted Toys. Plush or fur cloth covered toys are easily made by the home worker.

An odd length of white fur cloth can be utilized for the rabbit shown in Fig. 1. The main part of the body and the head are cut in one, but the underpart and the ears are added separately. A quarter of a yard of cloth, 48 in. wide, is needed, together with a little pink flannelette for lining the ears.

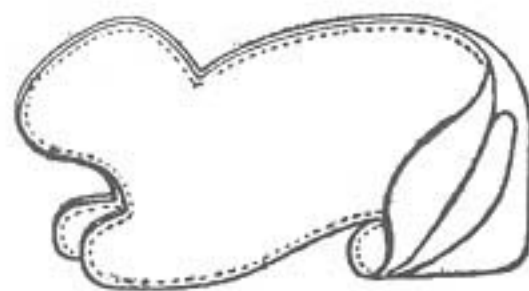
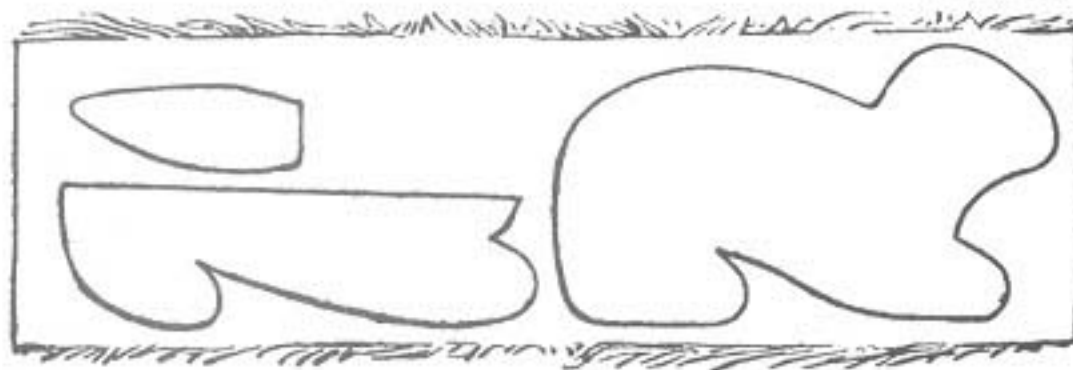
When cutting out, use the cloth folded with the selvages together, and arrange the patterns, cut to the shape shown in Fig. 2, in the positions there seen. First join the long, straight seam of the base or underpart; then take it, still folded, so that the seam runs along the top, but with the wrong side inside, and slip it between the two layers of the main body. The latter should be so put together that the right sides face.

Stitch the edges of each layer of the base to the edges of each layer of the main part, matching the sets of two notches, and also drawing the curved back part of the base down to the lower edge of the main part. Next stitch the two main parts of the body together above the inserted base portions, commencing at the front just below the head, and working around this and along the top of the body to the back of the inserted base.

Leave a small opening in one part of this seam, however, so that the stuffing may be put in. Turn the shape inside out, stuff it tightly with kapok, and



Toy. Fig. 1. Fluffy rabbit which is very realistic when made in white fur cloth



Toy. Fig. 2. Diagrams for making the fluffy rabbit, showing the shapes for ear, base and body, and how to join up the cover before stuffing →

then sew up the opening. Line each ear with the flannelette; then make a pleat in the straight edge and sew it to the head. Add two boot buttons for the eyes.

Patterns for other toys of this description can be obtained from "Best Way," 291a, Oxford Street, London, W.1. The latest "Best Way" book on Home-made Toys should be obtained at a newsagent's, as new patterns are frequently invented and described,

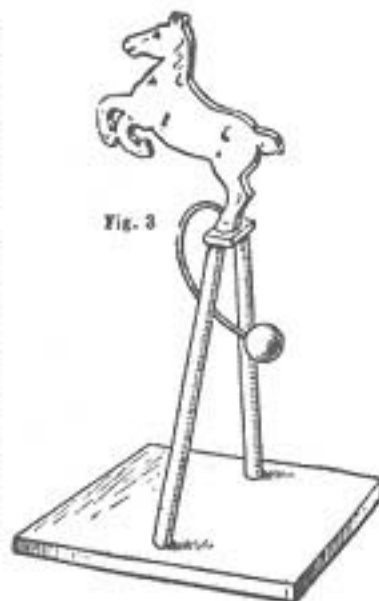


Fig. 3

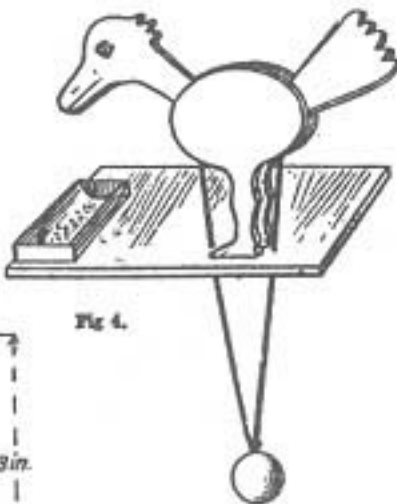


Fig. 4

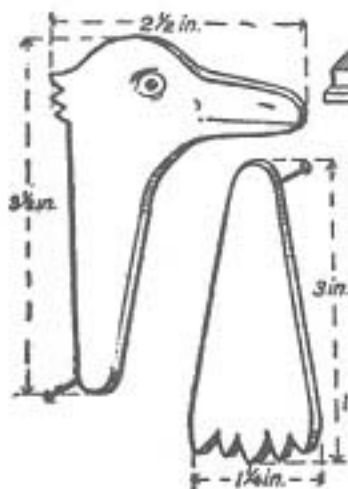


Fig. 3. Balancing horse cut from any hardwood and mounted on a stand, the pendulum being of lead. Fig. 4. Another balancing toy, a bird with hinged head and tail. Fig. 5. Component parts of bird

Wooden Toys. Toys can be made by the home craftsman from wood with a few simple tools. To begin with balancing toys, there is considerable scope for inventiveness with either the fixed or flexible balance. A good example of this kind of toy is shown in Fig. 3, in the form of the balancing horse. The outline of the horse, or any other animal, is marked out on a piece of thin wood about $\frac{1}{4}$ in. thick and cut out with a fretsaw. Any close-grained hardwood is suitable for the work, but with plywood there is little risk of breakage. The pendulum or balance should be of lead, which is cast in a plaster of Paris mould or in a well-greased tin lid. The wire is placed in the mould before the lead is poured in, and the other end of the wire is pressed into a prepared hole in the body or other suitable position on the animal. The stand is made from short lengths of dowel fitted in a wooden base; the uprights can be square in section provided sufficient space is allowed for the balance wire to move freely. It is not essential that the stand should be made, as the toy will act equally well on the edge of a table or shelf if the balancing wire is long enough.

Another form of balancing toy is shown at Fig. 4, string being substituted for the wire to hold the weight, and the various parts of the body hinged together. It is advisable to use a close-grained wood or 3-ply, the thickness of each piece being

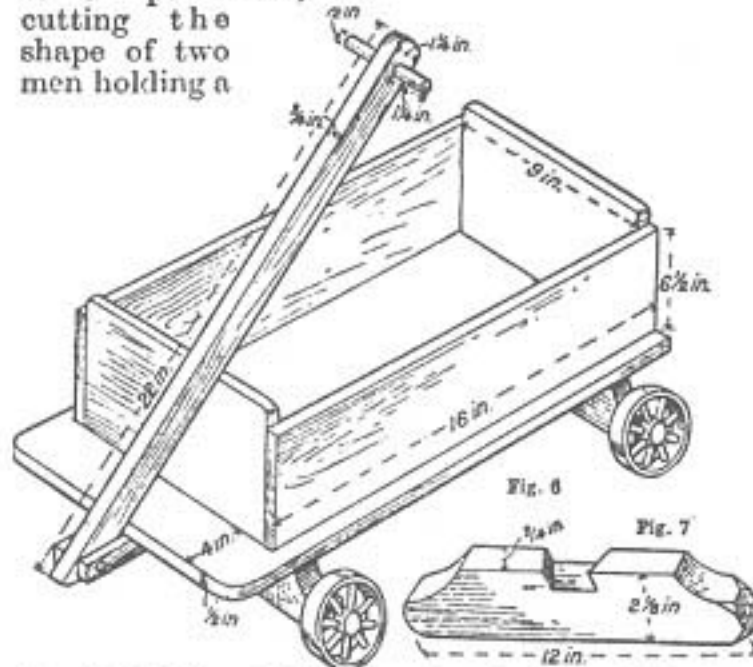
$\frac{1}{4}$ in. The various parts are shown in Fig. 5, and are cut out with a fretsaw; the two pieces for the body should be pasted together temporarily with a piece of paper between and sawn to shape, as this ensures their being alike. All edges and surfaces should be glass-papered.

The small pieces are glued to one of the body pieces in the positions indicated by the dotted lines. Small nails are driven into the ends of the

head and tail pieces, which should be further rubbed with glass paper to make them a little thinner than the small pieces attached to one of the body pieces. Holes are bored or drilled through the body and the head and tail for the hinge screws, and slightly enlarged in the two latter pieces to allow free movement. The balance

weight can be of flat shape, but with a groove or a hole through it to enable the string to be fastened. A round ball can be cast in the same way, and looks neater than the flat weight.

Each length of string should be about 8 in., but the longer it is the better, as the toy will work for a longer period. It is necessary to support the stand either by a weight at the back or a small G clamp. The toy can be made more realistic by fitting it on a platform and making a small food trough under the head. A development of this kind of toy is made by arranging two parrots on a strip of wood and connecting the strings to a pendulum, or cutting the shape of two men holding a



Toy. Fig. 6. Pole cart with small cast iron wheels. Fig. 7. Axle block slotted for handle fitment

hammer apiece and with these alternately striking an anvil, which is arranged between them.

The pole cart in Fig. 6 is composed of two sides nailed to end pieces and to a base. Cast-iron wheels are screwed to axle blocks, and the handle, which is fitted to a projection in front, is so arranged that it will not fall down further than an angle of 30° in front. The two sides are 16 in.

by 6½ in. by ½ in., the ends 9 in. by 7 in. by ½ in., and the bottom 20 in. by 10½ in. by ½ in., planed up and finished smooth, preferably from a hardwood such, for example, as birch or elm.

The sides of the cart should be securely nailed or screwed to the ends and the bottom attached in the same way. The axle blocks are 12 in. by 2½ in. by ¾ in. and must be of hardwood. One side is quite straight, and the other shaped to 1 in. deep at the ends from a line drawn 3 in. each side of the centre, and the ends cut off with a chisel to an octagonal form.

One of the axle blocks is screwed to the bottom board 1½ in. from the end: the other, as in Fig. 7, is slotted to take the dovetailed end of the projection to carry the handle. Plane up a length of hardwood to 11 in. by 4½ in. by ¾ in., reduce the end to 2½ in. wide, and cut a 2½ in. long by ¾ in. slot at the small end undercutting it ½ in. The dovetail to fit in the slot in the axle block should be sawn out and the piece glued to the block. A thin washer is cut from a piece of tinned sheet, and the axle block is screwed from the centre of the bottom and 5 in. from the end, with an ordinary washer under the screw head and the thin washer between the block and the bottom.

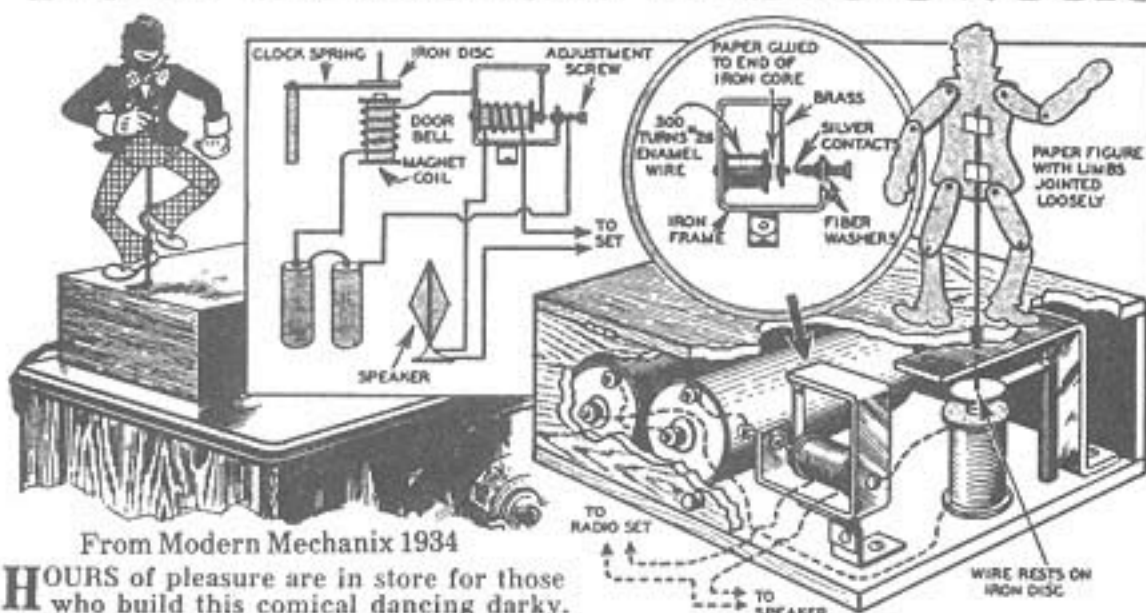
The pole or handle is planed to 22 in. by 1½ in. by ¾ in., one end is sawn off to an angle of 30°, and the other rounded and fitted with a 3½ in. length of ½ in. dowel. The handle is fitted to the slotted projection with a stout wire nail or a

rivet. The wheels should be 3 in. diameter, and preferably of cast iron. Wheels made of some close-grained wood may be used instead, or metal wheels fitted with rubber tires. The wheels should be attached to the axle by means of stout round-headed screws, washers being provided in the case of wheels fashioned in wood. The latter should also be bushed with a piece of brass tube.

In making a push horse of medium size, the body is cut to 10 in. from a round of 4 in. diameter, and flattened at the bottom; the legs are 10 in. by 1 in. diameter, tapering to ¾ in. at each end. The head is shaped from a piece of 5½ in. by 4½ in. by ½ in., and let in to a depth of ½ in. The base is 12 in. by 4 in. by ½ in., with 1 in. square lengths underneath to screw the wheels to, the latter being 2½ in. diameter and ¾ in. thick.

The handle is formed with two 18 in. by 1 in. by ¾ in. lengths, with a 4 in. length of 1½ in. diameter round between, these pieces being joined together with 1½ in. wire nails. The saddle and harness are usually formed with imitation morocco paper. The mane and tail can be made from a piece of an old skin rug. By fitting a projecting block to the front axle a pole can be fitted, as for the pole cart, that will enable the horse to be pulled instead of pushed.

DOLL DANCES to RADIO MUSIC



From Modern Mechanix 1934

HOURS of pleasure are in store for those who build this comical dancing ducky. He will jig for hours in step with the radio music, flinging his arms out wide for the peppier rhythms.

The output of a radio set is not great enough to operate this dancing figure, and so a relay and local source of power, such as two dry cells, are needed. A small sensitive relay easily made from scrap parts is connected in series with the radio speaker. This relay in turn operates the stronger electro-magnet which drives the figure.

The sensitive relay is similar to that used for "Black Sambo" in the March issue, except that silver contact points are added, the iron piece is placed on the inside of the armature, and a paper washer is glued to the end of the iron core to prevent sticking. The small silver contact is soldered on the armature. The adjustable contact is insulated from the iron magnet frame by drilling a small hole in the frame, plugging

it with a small piece of fiber, and drilling and tapping the fiber.

The armature frame is mounted on a swivel joint, and is rotated to adjust the center of gravity of the armature, thereby changing the sensitivity.

The electro-magnet driving the dancing figure may be made from an old doorbell magnet coil by changing the armature. A strip of spring brass or a piece of an old clock spring, with a small piece of iron soldered to one end, is mounted so the iron comes directly over the top of the magnet core. A metal bracket is mounted over the armature to serve as a guide for the driving wire. A hole a bit larger than the wire used is drilled in this bracket directly over the center of the armature.

The driving magnet is mounted in its cabinet, and a hole drilled through the top

above the iron piece. The wire carrying the light cardboard ducky passes through the holes in wood and bracket to rest loosely on the armature.



A Window Display

Popular Mechanics, 1913

A novel and attractive aeroplane window display can be easily made in the following manner: Each aeroplane is cut from folded paper, as shown in the sketch, and the wings bent out on the dotted lines. The folded part in the center is pasted together. Each aeroplane is fastened with a small thread from the point A as shown. A figure of an airman can be pasted to each aeroplane. One or more of the aeroplanes can be fastened in the blast of an electric fan and kept in flight the same as a kite. The fan can be concealed to make the display more real. When making the display, have the background of such



Paper Aeroplanes in Draft

a color as to conceal the small threads holding the aeroplanes.

DOLLS AND THEIR HOMES

With Details for Making a Doll's House

Cassell's Home Encyclopedia
England, 1920

While freakish dolls, sophisticated dolls in fancy dress and purposeful dolls, whose wired crinolines conceal a telephone or a bottle, are a matter of passing fashion for the grown-up, the real toy doll retains a permanent position as a nursery favourite. It may be of rubber or wood, or soft and cuddly of the knitted wool or plush-covered variety; it may be made completely of wax, china or composition, or have its face, arms and legs of one of these fabrics and the rest of its body of linen stuffed with horsehair or other material; it may possess an automatic equipment for walking and speaking, a wig of real hair and almost deceptive eyebrows, eyelashes and teeth, or it may be merely a sixpenny doll with no merit but the one common to any of the others, its capability of becoming the intimate friend of its possessor.

When grown beyond the stage of her first cuddly toys, a little girl is normally attracted by a doll dressed more or less as herself; small boys quite often like dolls dressed as soldiers, sailors, or Red Indians. It is certain that many girls who love their dolls do not want to bother about dressing or undressing them, but young children of both sexes will frequently be interested for hours playing with a doll's house and its furniture.

Easily Made Dolls.

Printed covers for rag dolls, ready to be cut out, made up and stuffed, can be bought at many toy stores. Having laid

such a cover flat on the table, with sharp scissors cut round the outline, leaving a narrow margin for making up. This is turned in, and if the seams are neatly oversewn on the right side stuffing can be done as the sewing proceeds. Kapok (vegetable down) is the best filling to use and should be well worked into the cover.

Another method, which can be used when an old bought stuffed doll is available, is to unpick the doll, remove the stuffing, iron the case to smooth out creases, and take the pattern of the old doll. It may not be necessary to go to the trouble of unpicking it, for if the shape is simple the pattern can be obtained by measurement. The old stuffing, provided it is quite clean, can be used to fill the new doll.

The diagram shows how to cut out and place pattern on material to make a doll. For one of medium size the distance from shoulder to knee should measure 10 in., and across hips 4 in. The

leg and foot are cut in a separate piece, also the arm (A, C, and B). For making the body-case, holland, glazed linen, or wash-leather is suitable. When the pattern is cut out place back and front together, right side inside, and stitch all round, leaving $\frac{1}{2}$ in. turnings. Leave the neck open for stuffing.

There are many different materials besides kapok that are suitable for stuffing dolls. Brown rugging wool, provided it is clean, is a cheap and soft filling. Flock is another material which can be used. Sawdust and bran give a good shape to the doll when filled. Before using, care must be taken that the filling is dry; this especially applies to bran, which, if packed damp, soon goes mouldy and smells unpleasant. Fine wood wool is much employed for stuffing dolls, and is suitable for big ones that will be subjected to hard wear.

This can be bought at glass and china shops.

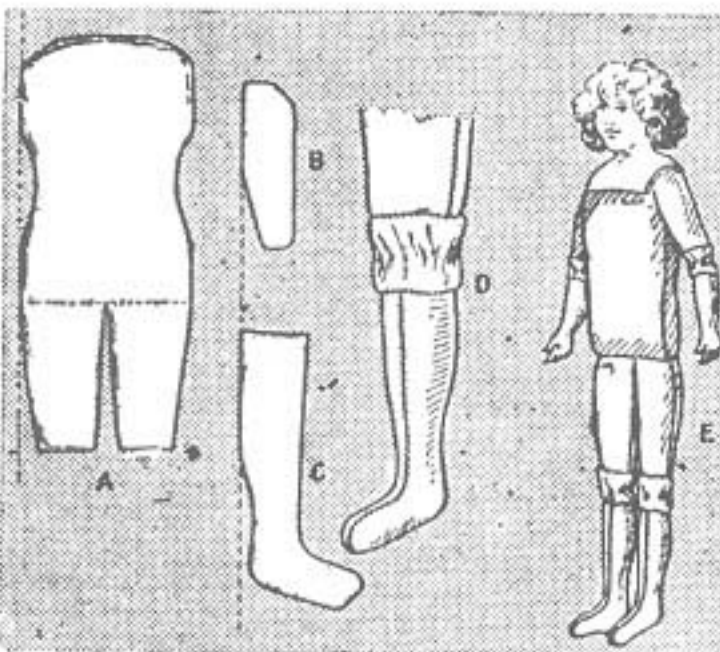
Whatever filling is used, it must be packed in tightly. Force it well down into the legs, using a pencil. When both legs are well filled and a good shape, machine or stitch by hand a straight line across the body; this forms the hip line. Continue to fill in the same way until the trunk is firm and a good shape. Close the neck with strong stitches placed closely together.

The lower leg and foot should next be made. When filled the leg is ready to attach to knee. The following

contrivance, which is extremely simple, makes the knee move as though jointed (D). Do not attach the lower leg directly to the upper leg, but instead stitch on a piece of the same material, $1\frac{1}{2}$ in. deep, from which the body was made around the bottom of the upper leg. Sew the top of the lower leg to the outer edge of this band of material. This leaves about $\frac{1}{2}$ in. between the two limbs, and will allow for movement sideways as well as backwards and forwards. The lower arm, wrist, and hand can be bought made in composition or plaster, and glued to the upper arm. Attach both arms to the neck.

It is better to buy a head, obtainable at toy shops at varied prices. The heads are provided with good shoulder pieces, which must be glued over the top of trunk and arms, thus doing away with unsightliness where arms join the body.

Clothing for the Dolls. Clothes for dolls may be copied from national or fancy dresses, but are



Doll. Stuffed doll, showing how to cut out the various pieces. The method of making a movable joint is shown at D

more often merely reproductions on a small scale of those made for girls, babies, and, to a lesser extent, boys. Their making is therefore only an adaptation of the ordinary principles of dress-making, knitting, etc. Usually the more nearly the doll's clothes resemble those of its owner the greater pleasure will it give; and the greater interesting occupation it will supply.

Socks can be made on fine needles, just a straight strip decreasing a little towards the end; when sewn together at the back, and pulled on to the doll's leg, they will shape themselves. Shoes may be made from old gloves and fastened on with a button and loop. A vest can be knitted or crocheted. A straight piece of knitting with stitches cast off in the centre for the neck and shoulders and picked up again to complete the back is all that is necessary. A crocheted border for the neck will allow of a ribbon or string to pull it up.

Patterns of dolls' clothes, together with detailed instructions for cutting out, etc., are sometimes issued with fashion periodicals, while various books and papers dealing almost exclusively with clothing for dolls and everything pertaining to the toy are obtainable.

Dolls for Christmas-trees, party favours, etc., can be dressed in crêpe paper. This can be bought from most toy stores in rolls of various sizes and in a wide range of colours. A combination of different shades is often successful.

Because of its fragile nature, crêpe paper should be sewn with care and a fine needle used. This precaution applies particularly to gathers where the thread has to be drawn up very gently.

Renovations and Repairs. There are certain dolls' hospitals in London and the provinces to which a damaged doll can be sent for repair. Now wigs can be supplied quite inexpensively, new limbs, new eyes, and new heads. The body of a large, well-made doll will stand two or even three decapitations, and be worth re-heading at intervals. It is quite possible to repair a broken doll at home provided the face is not cracked and ruined. Very often the back of the head gets crushed in. The best remedy is to stuff the head with paper or cotton wool and glue over the whole aperture a fairly large wig. The jointed limbs of dolls can often be fixed in again. In the case of a hair, wool or sawdust stuffed doll, the detached limb can be sewn on again securely.

If the body is of celluloid or composition the limb can be securely tied on with strong thread or very fine elastic. The latter is knotted through one limb, threaded through a coarse darning, and then drawn through the doll's body, and the limb on the other side attached. If the outer covering of the hair or wool or sawdust stuffed body becomes torn, a neat patch sewn over the hole prevents the doll from "bleeding to death." In the case of a cracked face, the only remedy is to melt a little wax from a candle and pour it into the crack, smoothing it first before it sets.

The Doll's House. An inexpensive, quickly made, strong and attractive doll's house is shown at Fig. 1. Oddments and 3-ply board are almost wholly employed in the construction of these houses, the whole nailed together, and the walls and roof covered with doll's-house paper. The front is constructed as two large doors which open over the ends and disclose the

whole interior with four roomy compartments. On the ground floor is a kitchen at the left, and at the right a lounge living room. The first floor may be used for two bedrooms; or the right-hand half may have a partition across, making space for a bathroom. In the lower lounge there is room for a neat staircase. The roof is so built that it may be lifted off; elevations and plans shown are drawn to scale. The elevations and plan at Figs. 2, 3, and 4 will give sizes and quantity of timber. Fig. 6 shows how the skeleton framework is built. There are four corner posts (A), for which lengths of about 2 ft. by $\frac{3}{4}$ in. square will be wanted. The middle upright (B) is the same length, but 2 in. wide by $\frac{1}{2}$ in. thick, and is rebated for the partition (C), which will be 3-ply board. The bottom (D), ends (E), and back (F) are 3-ply, nailed on. The top (not shown) is also 3-ply, the same size as the bottom.

The 3-ply floors (G) are cut at the corners to fit the posts, and fixed to narrow mould nailed to the 3-ply sides and partition. The right-hand floor (G) should be cut back in the middle as indicated to allow for the recessed doorway part.

The front is a pair of large doors, hinged to the posts (A), and opening from bottom to top. The left-hand door, 13 in. wide, shuts on the upright (B), which is a fixture. The right-hand door is 17 in. wide, and includes the recessed doorway portion of the house. Thus, the right-hand opening front is not flat, but has a break (Fig. 8). The fronts of the house may be of $\frac{1}{2}$ in. wood, with battens top and bottom.

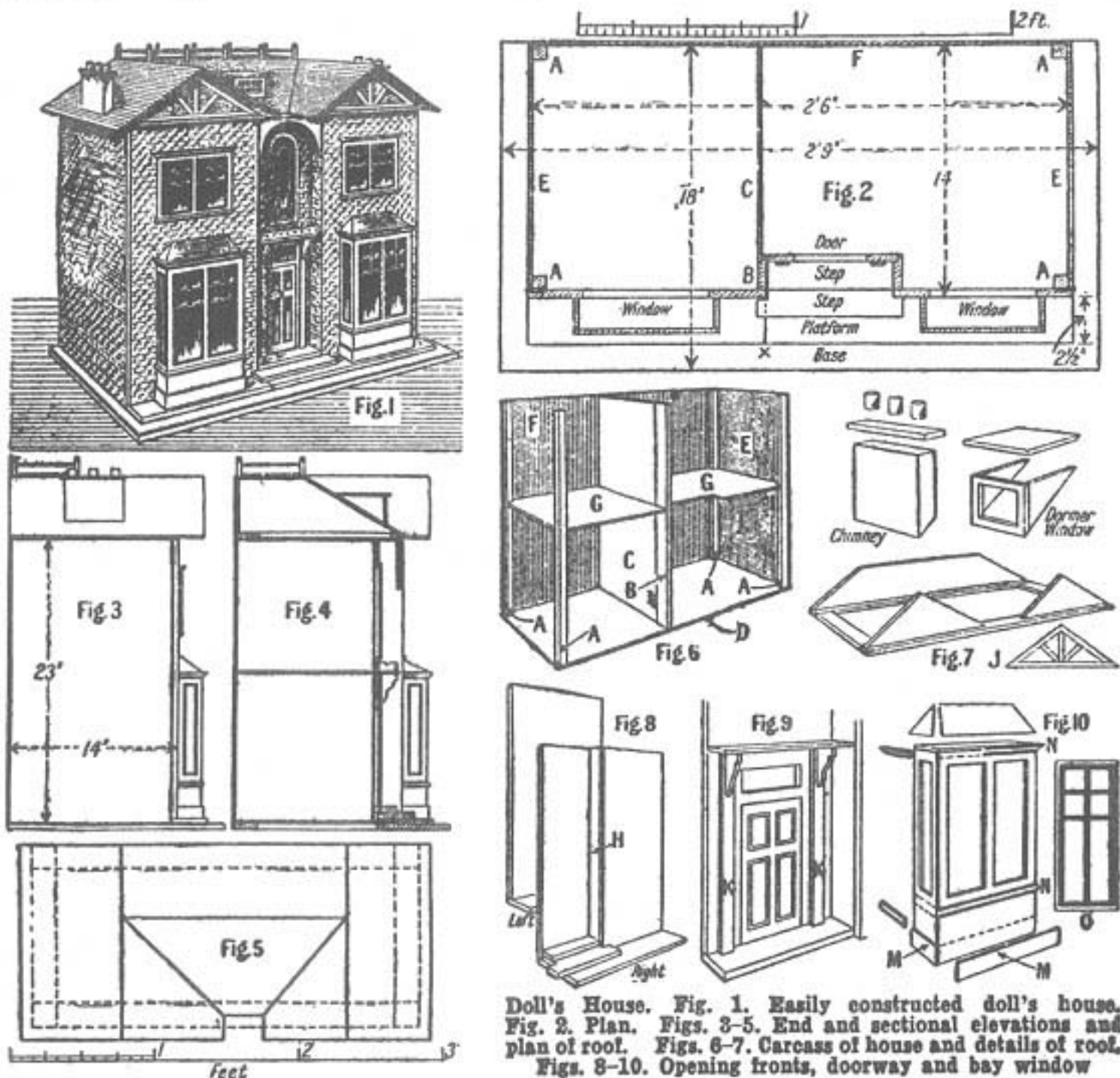
Screwed to the underside of each opening front is a $\frac{1}{2}$ in. platform which carries the bay windows. This platform is 30 in. long by 3 in. wide; but, as it opens out with the doors, it must be cut across as at X on plan (Fig. 2). At Fig. 8 are given outline perspective sketches of the left and right opening fronts as they will appear in carcass. The bay windows and doorway are not shown on this sketch. The narrow break piece (H) should be of $\frac{1}{2}$ in. wood, nailed to the main parts of the little building.

Constructing Door and Roof

Each door should be hinged with three good butts, and the platforms should be raised about $\frac{1}{2}$ in. from the base. The base of the house may be framed up of $\frac{1}{2}$ in. or $\frac{3}{4}$ in. material, halved at the corners. The front stile will be 6 in. wide; the back stile and rails may be 2 in. A stiffening centre rail 2 in. wide should be added.

A scale plan of the roof is given at Fig. 5, and at Fig. 7 a simple method of its construction. First make a frame of $\frac{1}{2}$ in. material, 32 in. by 15 in., to overhang 1 in. at front and sides, but flush at the back, halved at the corners, with four holes bored to enter dowels fixed in the top. From Fig. 7 it will be seen that two gable pediments and a back piece (all of $\frac{3}{4}$ in. material) are nailed to the frame. Over these the 3-ply roof may be laid.

The shapes of the three inner slopes should be cut in stiff paper to secure the correct angles. The flat back portion of roof is approximately 18 in. by 6 in., and will take a balcony rail. The front gables may be overlaid with $\frac{1}{2}$ in. fretwood cut to width of $\frac{1}{2}$ in. The arrangement of the strips is shown at J, Fig. 7.



Doll's House. Fig. 1. Easily constructed doll's house. Fig. 2. Plan. Figs. 3-5. End and sectional elevations and plan of roof. Figs. 6-7. Carcass of house and details of roof. Figs. 8-10. Opening fronts, doorway and bay window

The doorway has two steps, $\frac{3}{4}$ in. or $\frac{1}{2}$ in., the lower one cut back close on the left-hand hinged front (Figs. 2 and 8). The door pilasters (K, Fig. 9), of $\frac{1}{2}$ in. fretwood, $10\frac{1}{2}$ in. long by $\frac{1}{2}$ in. wide, are surmounted by a ledge supported by two shaped brackets. The ledge may have an ornamental rail as shown in Fig. 1. The door may be 8 in. by 4 in. with $\frac{1}{8}$ in. veneer mounted on to form panels. The fanlight above will be treated as a window. The arch shown above the doorway should be of $\frac{1}{2}$ in. or $\frac{3}{4}$ in., set back about $\frac{1}{2}$ in. from face of the house front. As the arch opens with the right-hand house front, it must be made rigid at the left-hand side by gluing in a small piece of wood to secure it in the recess. The lower step may be cut flush with the upper one, so that the left-hand door may be made to open before the right-hand one.

Fig. 10 shows the bay windows, of $\frac{1}{2}$ in. material with 3-ply roofs, the plinth (M) and moulds (N) being glued on. The upper windows are made up of $\frac{1}{8}$ in. fretwood glued on in strips. Narrow moulds are planted on above and below. All windows should be glazed, the glass being beaded

in. To secure the effect of sashes, strips of narrow veneer may be glued to the glass as at O, Fig. 10. The construction of the little dormer window, shown at Fig. 7, calls for no comment.

The chimney stack (Fig. 7) is a block of white-wood 5 in. wide, $3\frac{1}{2}$ in. high and $1\frac{1}{2}$ in. thick. Above is a flat piece of $\frac{1}{2}$ in. fretwood, and three short lengths of 1 in. dowel rod will serve as chimney pots. For the top balustrade the posts may be $\frac{3}{8}$ in. square by $1\frac{1}{2}$ in. high. Between these, on the roof floor, are glued strips of fretwood $\frac{3}{4}$ in. wide; whilst the rail itself may be $\frac{1}{2}$ in. beech dowel rod with little turned balls on the post tops.

Interior Decoration and Furnishing

A special feature should always be made of the outside and interior decoration of a doll's house, for it is this touch of reality that appeals to the child. The exposed woodwork may be painted a soft cream, the stand green, and the chimney pots red. The outside walls should be covered with doll's house red-brick paper, and the roof with tile paper. For the inside a great variety of miniature patterns is available.

If the floors have been smoothly planed, they can be stained, but if rough, it is better to carpet them all over, cutting the carpets from plain thick cloth. The floor of kitchen and bathroom can be covered with American cloth, and little rugs can be made in woolwork or canvas. Long side curtains of thin printed or plain fabric cretonne or casement surmounted by a little frill in the same material across the top of the windows look well. Little net or muslin half curtains can be placed across the lowest sashes.

Charming little beds can be made out of note-paper boxes, chocolate boxes, etc., arranged so that the lid of the box forms the head of the bed, and trimmed with a frill of muslin to form valances and curtain. Mattresses and pillows stuffed with cotton wool, and calico sheets, are added. The bed curtains in the different rooms can be tied with different coloured ribbons and the coverlets made of ribbon to match. An eiderdown can be made by stitching up about 12 in. of 5 or 6 in. wide satin ribbon to form a

bag, stuffed with a layer of wadding. The bag is then sewn up, and the rows of stitching added by machine, which produce a facsimile of an eiderdown quilt.

The kitchen equipment should include a stove, pots and pans, wash-tub, mangle, irons, and all the usual outfit. Tiny brooms can be made by tying a few wisps of fibre to a thin skewer or a few little feathers to a matchstick. A set of kitchen towels, dusters, etc., can be made, and, of course, the usual complement of cups, saucers, plates, etc., obtained. Sets made of aluminium are quite inexpensive, and minute cutlery, spoons, forks, etc., are obtainable in tin.

Doll's furniture may roughly be divided into two classes. There is the miniature furniture that a child can use with her dolls on the nursery floor—chairs, tables, beds, etc., made on a scale proportionable to the size of an average doll. Then there is the toy furniture used to decorate the doll's house, miniature suites and pieces of which are obtainable in a great variety of styles.

Decorative Wire Working

With a drawplate, either purchased or homemade, you can develop a variety of ornamental shapes



When drawn to the correct size and shape, the wire may be twisted by hand or, more conveniently, in a lathe with a hollow headstock

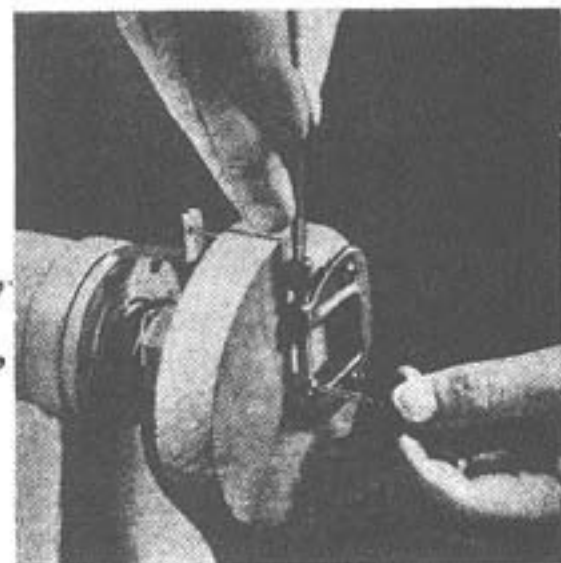
ONE of the most useful workshop tools is the drawplate, with which the diameter of various kinds of wire can be reduced and the length correspondingly increased.

With certain types of drawplates the shape of wire also may be changed. Square, half-round, oblong, triangular, and other wire shapes have unlimited possibilities for decorative purposes. Alone,

twisted, or in combination, they can be used for ornamenting metal and wood projects as well as for making chains, jewelry, and articles of that nature.

Commercial drawplates, which are made of very heavy steel and are accurately cut and tempered, are recommended, but when cost is a consideration it is practicable to make one. The principal tools required are a fine drill and one needle or

escapement file of the desired shape for each different style of hole.



About the best steel commonly available is a discarded circular saw blade, the thicker the better. Remove the temper by bringing it to a red heat over a gas flame and allowing it to cool slowly. With a metal-cutting saw, remove an oblong section. A piece $2\frac{1}{2}$ by 6 in. is large enough for three sets of holes.

After scribing two or three lines across the plate, make equally spaced prick-punch marks along each for the primary holes. Use a drill that is slightly smaller than the smallest hole is to be when the plate is completed. With a larger drill, countersink the holes for about half the thickness of the plate, no more.

Slender, needle-pointed escapement files can be obtained in round, square, triangular, and other shapes. Use merely the point of the file for shaping the smallest hole; for the next larger hole, sink the file a fraction of an inch deeper, and so on. Smooth up each one to reduce friction. A cone-shape opening is most satisfactory.

To restore the hardness of the metal, wrap the plate with several turns of iron wire, then suspend it over a gas flame until it is an even red. Immediately plunge it into a pail

By
**KENNETH
MURRAY**

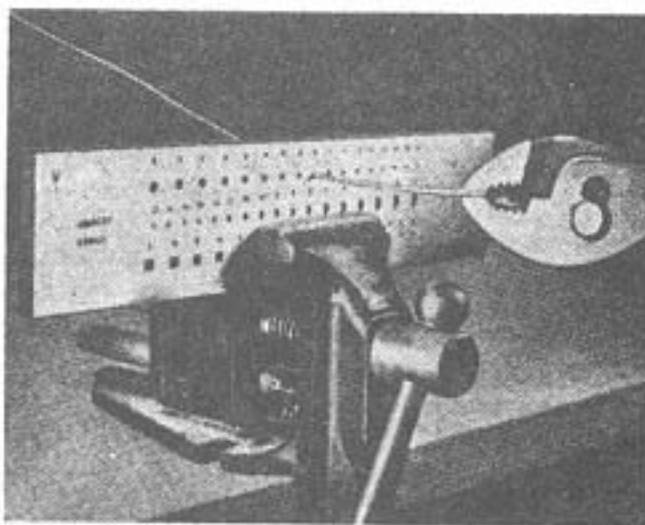
Popular Science
April 1937

or pan of cold water. To temper, *cautiously* reheat it until the steel takes on a straw-yellow color, then again plunge it into water. Clean a part of the surface with emery cloth to see the color better.

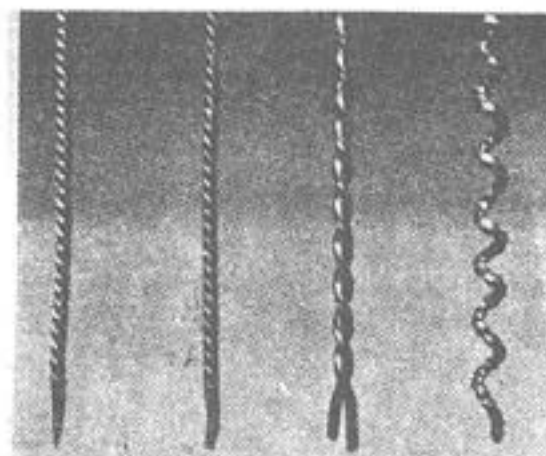
Special drawing tongs are made for this work, but it is satisfactory to use ordinary pliers if the mouth is first filed smooth and flat. The end of the wire to be drawn must be filed to a point, and the whole wire should be well oiled.

By drawing it through successively smaller holes, the wire will become springy. Care must be used to avoid injury in case the end springs back after leaving a hole. The springiness indicates that the wire requires annealing. Short lengths can be annealed by drawing them slowly through a gas flame, allowing them to become red. To anneal considerable lengths, it is best to make the wire into a coil and suspend it over the flame with a piece of iron wire. A short dip in nitric acid will remove the coating of black oxide, but this need not be done until the wire is of the size wanted.

Annealing is necessary before twisting, which is the method used to make the wire decorative. While the wire or a combination of two or more wires could be twisted by hand, a more practical way is to use a lathe with a hollow headstock spindle. First cut a 1-in. thick wood disk, drill a hole through

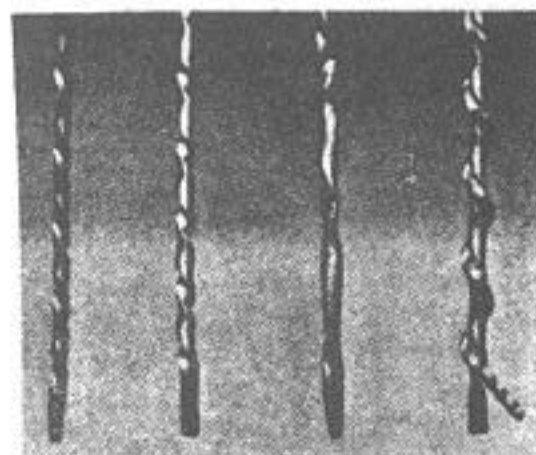
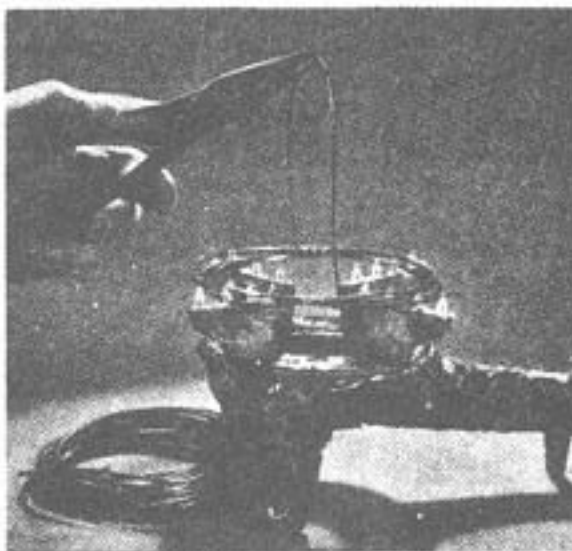


Drawing wire through a typical commercial drawplate with a variety of round, half-round, and square holes



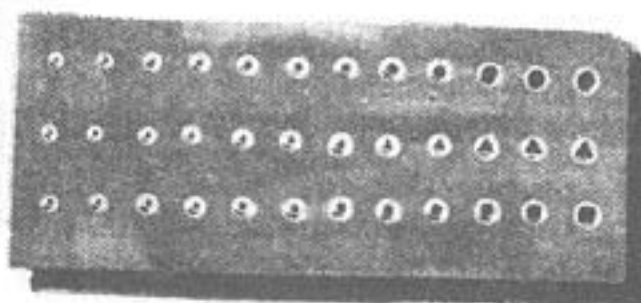
Square wire twisted at intervals . . . twisted in alternating directions . . . square wire given a slight twist . . . square wire with a very tight twist

Square wire twisted, passed through square drawplate hole . . . same, passed through round hole . . . square wires twisted together . . . twisted, wound on wire, and removed

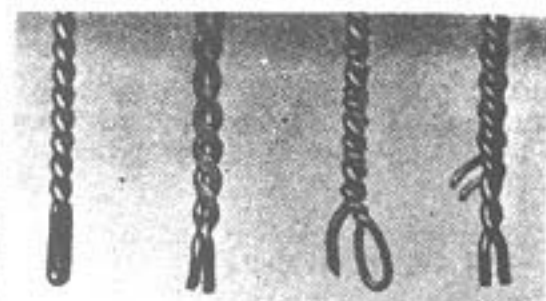


Half-round wire twisted, drawn through round hole . . . with loose twist . . . with twists alternating . . . twisted, then wound with square twisted wire. Left: Annealing a coil of wire to soften it before twisting

In the tempering process, reheat the hardened drawplate over a gas flame until it takes on a straw-yellow color. It is then plunged in water



A completed homemade drawplate with three series of graduated holes for round, triangular, and square wire

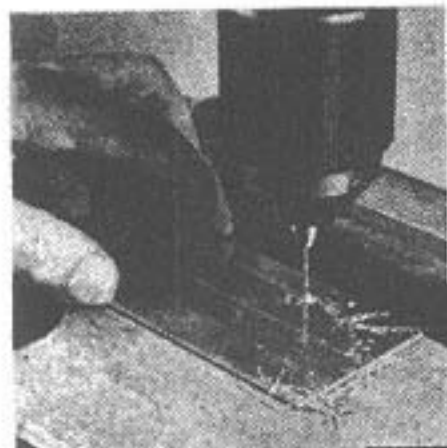


Left to right: Round wires twisted . . . flattened . . . twisted with another round wire . . . two large twisted, and two small wrapped around

the center, and then screw it to a faceplate with a center hole so any length wire can pass through. To the face of the disk, screw a C-clamp so that the jaws meet at the center of the hole. Cut a slot in the knurled screw head of the clamp to enable it to be tightened with a screw driver. A further refinement is to attach a strip of light spring brass to the headstock bearing case so as to engage a pin driven into the back of the wood disk, near the edge. This will cause an audible click so that the turns may readily be counted. In twisting the wire, it is merely gripped with the C-clamp as illustrated, and the other end seized with pliers. The lathe must be operated by hand, and an easy way is merely to pull the belt downward.

In addition to changing the shape of wires for decorative purposes, the drawplate has another very important use in every workshop—it makes unnecessary the stocking of a large assortment of wire in the different gauges. If you require a piece of fine copper wire, for instance, there is no need to grope in the junk box or rush to the nearest hardware store and purchase a spool. Merely clean the insulation from 1 ft. of common electric wire, pass it through the drawplate a few times, and you will have from 10 to 20 ft. of wire of the exact size required for any particular job.





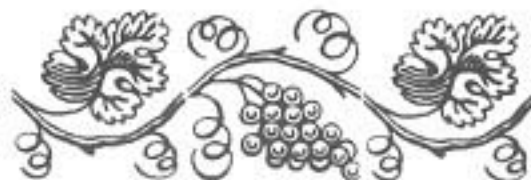
The first step in making a drawplate is to drill and countersink the primary holes. Then support the plate as at the right, with a light below, and shape the holes with files



This cigarette humidor and ash tray is an example of the countless craftwork projects that may be decorated with various forms of twisted wire



Square wires twisted separately, then together . . . two sets round, twisted separately, then together . . . flat, with loose twist . . . same, tight



WEAPONS BEHIND THE WALLS

By Mike Brown

Imagine a survival course that would transport you back into the Dark Ages. A course that would enable you to do almost anything. Barter, improvise weapons, escape, kill. Achieve razor-sharp physical fitness. And, above all, be able to out-smart almost anyone. Power politics, deception, psychology; all these subjects and more. Would you enroll?

Or, suppose you were offered a job at \$4.00 an hour for primarily just standing around. You might eventually make \$35,000 a year. There is also the opportunity to pick up \$10,000 a year or more for a few hours work. The risk is minimal. Even if you are apprehended, the most time you will do is six months. You might even retire wealthy.

Which one would you take?

But there is a catch to both. In the first, you might not be willing to pay the price. In the second there is a weird rule you must follow: you are not allowed a weapon, yet you must supervise men more heavily armed and more intelligent than you are used to dealing with. Your job is to control them.

These survival methods are learned in a U.S. Prison, and the cushy job is what a guard does. Things in prison are far different than what you see on TV, or read in books. It is assumed that guards and other personnel run the prison. However, the prisoners actually run the prison: this is borne out every time the prisoners go on strike. Normally, prisoners run the prison industry, the repair shops, and take care of any paperwork that needs doing. In a strike everything shuts down.

POST SURVIVAL CONSTITUTIONS

By Kurt Saxon

Many readers have written suggesting that I lay out a groundwork for a future constitution. The idea that I am competent to write such a document may seem presumptuous. But I am competent to set down a system of fundamental laws and principles of a government. So are you.

Of course, any old lady can write a good, working constitution for her garden club and set up officers who will keep the club solvent and growing and fun for its members. That's all it really amounts to.

Even so, a constitution which depends on future generations for its acceptance must be more involved than club and organization constitutions, since it will affect people who will reject it no matter how good it is.

Well, you can't please everybody and constitutions are written, not to please everybody, but mainly to please those leaders who wrote it and for whose interests it was written. Regardless of the inspiring garbage written about the Magna Carta and the U.S. Constitution, both documents were exclusive and ignored the interests of the general populations.

Once in a Sydney bar, I was fascinated as a drunken Australian scholar held forth on the Magna Carta. He said it was the greatest document of liberty ever written and had made him a free man. Indirectly he was right. But only indirectly, as the Magna Carta was not written for the common people. Many amendments had to be written, after his ancestor had been transported to Australia in chains. While the Magna Carta was England's charter, my main ancestor on my mother's side was sold out of Newgate Prison to a Colonies bound ship captain to be resold for a period of seven years' servitude to an affluent Colonist.

After the American Rebellion, our forefathers decided they didn't want the British to dump their vermin and misfits here so the ancestor of my Australian friend was dumped at Botany Bay, instead. So the Magna Carta was not even a guarantee that a citizen could remain on his native soil.

The Magna Carta was written, not for the English people, but for the Nobility. King John believed he owned England and all its people. The Nobles believed they should share this ownership, partly because they wanted more power and partly because they didn't want to be owned themselves. The main thrust of the Magna Carta was against the Divine Right of Kings. But it originally had few restrictions against the power of the King and his Nobles over the common people.

It didn't remove the collar from one serf. Nor did it restrict the slave trade,

In Lewisburg in 1975 the convicts struck. I was working in the machine shop at the time and looked out the window to see several hundred convicts milling in the yard. Since it was my first year in the joint I mis-interpreted what was going on and went for a weapon. The shop was full of them—heavy iron bars, sharpened pieces of metal, and an occasional .38 revolver such as three convicts had made in the machine shop and then destroyed when they realized they would never make parole if they were caught. One colored fellow did lose his parole date because of what he did in our shop. He was making counterfeit plates for various denominations of federal reserve notes.

About the time I found a satisfactory length of iron pipe other convicts came running in the shop yelling "strike" and I put down my iron. I thought a riot was coming. Within seconds the loudspeakers blared for all prisoners to return to their cells.

As we walked to our cells I could see the guards were edgy. If the convicts rioted they didn't have a chance. There were hundreds of us. There were a few dozen of them. Many of us were armed. None of them were. Guards in the towers had carbines and shotguns but they were of little use to their fellow officers: their field of vision was limited to the prison wall and the yard. Anything that happened inside was going to be over before they could react.

The guards were nervous. They came and got us cellblock by cellblock to eat. There were eighteen men in my block (I was in maximum security, with smaller population than the other cellblocks) and we were taken to the mess hall in a group, ate in a group, left in a group, and after we were locked up the next block was let out to eat. Some blocks didn't get fed until almost midnight. Normally cellblocks are let out to eat at ten-minute intervals. Normally, feeding the entire population of over 1500 takes under two hours. This time it took six. Pulling the industry supervisors and guards out of the prison industry to wash our dirty dishes and trays didn't speed things up.

After the strike I was approached by another convict next to me on "A" block. He asked me if I wanted to buy a .38 Special with a box of shells for "400 green" ("green money" means cash and is contraband inside the walls). I laughed in his face. If I needed a gun I could have one made in the machine shop but nobody could convince me that Smith & Wessons and Colts with boxes of ammunition floated around inside the prison compound.

A week later the whole prison adminis-

whereby the British forcibly recruited brute labor from Africa, nor did it restrict press gangs whereby the British Navy forced its citizens, and finally even American seamen into its service.

The U.S. Constitution did not include non-whites. When it mentioned men it did not include black men or Indian men, and it certainly didn't include women. Only generations later were all citizens covered.

It gives me a laugh to hear black agitators and Lesbian Libbers screaming about their Constitutional Rights. Our prisons are filled with people our forefathers would have hanged after about five minutes of testimony. Our dwindling resources are being squandered keeping Welfare vermin alive, few of whom would have survived because of anything written in the original U.S. Constitution. Then there is the billions in foreign aid given to governments our founders would not have helped to continue.

Constitutions are usually written by idealists on behalf of those who will assume the power of the State. As such, they are generally beautifully written but are revised by the self-serving leaders to fit their own purposes. For instance, Tom Paine wrote the Declaration of Independence and drafted the Constitution. Thomas Jefferson, the supposed writer, deleted the anti-slavery clause. This was because he was keeping maybe three printers busy turning out reward posters for his own runaway slaves.

So a constitution is simply a prettily written document which divides power between members of a new government. After it's served its purpose for the founders, future leaders will redo it to insure themselves the same place at the public trough the original gave to the founders. Our Constitution has been so perverted on behalf of Liberal political trash and their degenerate electorate that it is now more a danger to decent people than a guarantee of their liberties.

Most constitutions are more enlightened than those they replaced. All too often, however, they prove inadequate after a few years and have to be amended and added to by future legislators. Regardless of the sincerity of the original authors, as time goes on, many other amendments are tacked on just to please special interest groups. Then other amendments are put in to glorify the memory of politicians who just want to be remembered.

As the system evolves, so many amendments are tacked on and so many new laws are enacted that a constitution, along with all the city and state ordinances becomes just a big pile of confusion on paper.

In no time at all, a society's laws become so muddled that special people are appointed to interpret them. Any document, or set of documents, written in a nation's language, which needs interpretation should be destroyed.

Even so, the need for interpretation is unavoidable as a system degenerates. When a populace becomes so large in numbers, so diverse in common interests, so divided by differing minority demands that satisfying an individual or group detracts from the security of others, the need for interpretation becomes unavoidable. But, regardless of the need to try to be fair to everyone, all such attempts simply worsen the situation.

Over half of the adult American population is semi-literate. Millions of mental defectives require Welfare and millions more ought to be liquidated as dangerously anti-social criminals, most of whom are running free lest their "Constitutional rights" be violated. The observance of their Constitutional rights threatens the life, liberty and pursuit of happiness of everyone around them, resulting in unresolvable conflicts. This alone is enough to invalidate the U.S. Constitution.

As the world situation deteriorates, all constitutions will become worthless. Civil populaces will go berserk, followed by their respective governments. A few years from now the world's cities will be gutted piles of rubble through the civil strife and/or war.

The rebuilding of civilization will be up to people like you. You'll probably write a constitution yourself. And what kind of constitution will you write? Will it favor the laborer, the farmer, business, your own little power structure? You won't be alone, regardless of whom you favor. Every writer of a future constitu-

tration was in an uproar. A colored guard walked into the prison and put what appeared to be his lunch, in a paper sack, on another officer's desk. Someone called this guard over the loudspeaker and asked him to move his car from a no-parking zone. He went out and left his "lunch". The other officer picked up the paper sack to move it off of some papers. Wondering why a sack lunch would weigh six pounds, he looked inside. He saw a .38 S & W with a box of bullets.

The men he was doing business with wouldn't squeal and so the government wound up with a case consisting of hearsay, not enough for a criminal conviction. The guard lost his job.

I hadn't realized at the time that the convict offering me the gun for "400 green" was trying to do me a favor; that was what the guard was charging for them. About two dozen revolvers had been sold inside the walls and hidden in various places by the purchasers. For reasons known only to himself the colored guard sold his guns only to the white prisoners. One of them, doing 45 years for airplane hijacking, evidently used his purchase to commandeer a garbage truck (with the help of two other prisoners), peg a couple rounds at the tower guard, and run through the front gate in August 1974.

Later I was introduced to other prisoner favorites in weapons; explosives and fire.

I didn't think explosives were available to prisoners. Once in awhile someone would set off a match-head pipe bomb or similar crude device but I never suspected anything sophisticated.

One prisoner had gotten extremely tired of other prisoners stealing his radio. He would engrave his prison number on it, take it with him to the gym, and invariably whenever he turned his back another inmate would run off with it. He decided to teach someone a lesson. He wired his newest radio with explosives and left it in the corner of the gym. He walked away from it. Someone walked off with it. Whoever got it turned it on while walking down the stairs and the charge went off. A ball of black smoke drifted back into the gym. Nice try, but the victim of the blast was a guard who had picked it up to return it to its owner.

By the time I was released three years later bombs in the compound had become so commonplace they were boring. An explosion the size of a hand grenade in the yard didn't even disturb the guards.

Fire in the prison was far more deadly. Referred to as "burn-outs", they usually took one of two forms. The first was to simply soak a cell with flammable liquid and set it to the match. This was a polite

tion will be tempted to look out for his own interests. But will your interests, at the time of the writing, be the same years later? Will it serve the interests of the next generation, and the next? Probably not.

The coming crash of world civilization was predicted in 1803 by Thomas Malthus. He proved that populations grow geometrically. That is, a population can double itself within a single generation, then double itself again in another. On the other hand, an acre of land will not double its produce every season. More water and fertilizer, insecticides, hybrids, intensive cultivation, etc., can double and even triple an acre's produce. But within a few planting seasons the limit is reached, while the population keeps on doubling itself generation after generation.

Rather than accept Malthus' findings, misguided idealists have gone further afield, utilizing marginal land, looting the oceans and generally destroying the environment to accommodate more two-legged vermin. Do-gooders, mainly among the Western nations, even campaigned to outlaw the traditional destruction of the surplus and congenitally unfit. (See INFANTICIDE, page 583).

At this time, no constitution can possibly accommodate all individuals and minorities. Industrial workers, managers, businessmen, racial minorities, mental defectives, criminals, religious and political groups, the elderly; all want their share of an increasingly diminishing pie. There's just not enough resources, both in goods and services, to go around.

As constitutions are generally written, the same cycle repeats itself over and over again. Think back to Egypt, Babylon, Greece, Rome and all the elaborately organized societies since, and you'll see that the special interest groups founded the societies and gradually accommodated other special interest groups, largely from among the degenerate sub-cultures of that society. So even if the society had Utopian potentials, its less able members were allowed to multiply, eating up the surpluses, crowding the living space and finally dooming the system. Throughout the ages, idealistic constitutions have doomed more societies than have wars.

The only practical constitution must deal primarily with population control. Again, such a constitution could be just as negative and destructive as most others if the population controls were repressive against the able among the non-affluent or racial minorities. Such repression is a breeding ground for agitators and no society can spare the manpower to implement such programs.

To insure the public well-being on a permanent basis, population control must be fair, even toward those least able to benefit society. Rather than allow the unfit to reproduce and then punish them and their degenerate offspring, sterilization would keep them from enlarging their social dependency and allow them a better lifestyle on what little income they can scrape up.

Following are a few points I would put at the head of any constitution:

- (1) Only those married couples who are physically and mentally healthy and economically solvent will be allowed to bear children.
- (2) No more than two or three children will be allowed each eligible couple.
- (3) Following conception, a prospective mother must eat only fresh, unadulterated foods in as wide a variety as the general economy will allow.
- (4) Children must be with the mother constantly from birth until weaning with no paid work outside the home or garden.
- (5) All children must be breast-fed for at least six months.
- (6) No woman will be permitted medications, prescribed or over-the-counter, stimulants, alcohol, tobacco or any sort of narcotics after conception and before weaning.
- (7) Any parent who deliberately injures a child must be sterilized and the child, or children must be put up for adoption.
- (8) All pregnancies by unwed females must be terminated.
- (9) Abortions must be given upon demand, regardless of the reasons given.
- (10) No citizen congenitally unable, or conscientiously unwilling to defend the system will be allowed to reproduce.

For explanations of the need for the above proposed laws, see pages 64, 84,

way of letting the cell occupant know that he was considered persona non grata by the other residents of the cellblock. The second form of burn-out was far more serious. The idea was to kill. If the man was locked in his cell and a firebomb was thrown in, death was automatic. If the cell wasn't locked he still didn't have much of a chance since his killers would brace the door shut with a wedge-shaped piece of wood or the sides of their feet. Firebombs were easy to make, if gasoline from the power lawnmowers and soap from the laundry wasn't available there was always shoe polish. Melted shoe polish, turned to a liquid and placed in an open container, was easily ignited and tossed into a cell. It not only burned, it stuck to the victim. Just like napalm.

Bombs, guns, and knives are obvious weapons to anyone. But prisoners often run in packs and operate like armies. Which includes communications and intelligence. Sometimes with fatal results to federal employees.

In "A" block in 1975 I had a conversation with a convict out of Leavenworth. He was "doing it all" (couldn't make a parole) off a five-year sentence and about to get out. When I inquired as to his lack of parole eligibility he explained that, in a cell with seven other men, the guards found an FBI agent with his head severed from his body after the prisoners had left for work call.

The FBI agent came in after the evening meal when all convicts were supposed to be off work. One convict in Receiving and Discharge was still there (R & D is where prisoners are processed in or out). He saw the agent turn in his gun, badge, and put on prison khakis. The prisoner left R & D without being seen and communicated the facts to the convict population.

The agent walked into his death cell and offered to buy narcotics. No one offered to sell him any and the next morning he was dead.

Oral communication wasn't the only method the convicts used. An electronics wizard showed me how to take two radios, put them exactly on the same channel (I forget whether AM or FM but you can find out yourself in 30 seconds) and tap on the speaker of one of the radios. The tapping will be audible from the speaker of the other one. This individual was sent out to the prison farm to keep him from teaching the rest of us what he knew. Not, however, before I got a schematic of a blue box and excellent working knowledge of how to build and operate a red box. Our electronics genius was doing three years for one \$9.11 phone call.

All the foregoing is simply what was available inside the prison. Other trinkets could be ordered. Some convicts in

Vol. 1 and page 583 of Vol. 2 of THE SURVIVOR.

If these ten simple rules were made law, there would be few social dependents, fewer criminals or other anti-social types. Without these rules, no society can long avoid the upheavals we face.

With them, there would never be a reason for the society to launch an aggressive war.

There would be little poverty. Social strife would largely be confined to debates. Social progress would be built on the development of science and technology, rather than at the expense of the environment or neighboring systems.

No matter what kind of constitution you laid out, there would be no politicians, as we know them. Without the mental defectives produced by other defectives born to even more defectives, the politicians would not have the degenerate electorate which has consistently voted away our potential for national survival.

You may have the chance to break the cycle of growth, stagnation and then decline, which has laid waste to our planet's highest civilizations. But without the resolve to insure the rights of all your culture's children, your own rights will be eroded by irrational children in adult bodies.

Aside from a set of population control laws such as listed above, you ought to forget constitutions at this time. Let the next generation write the Constitution. For once, let a constitution be written, not for a society already fixed in pettiness, avarice and stupidity; to cater to their irrational fantasies. Rather, let it be written by and for a sane, brave, intelligent and industrious people, born well, reared well and fully able to govern itself without any dictums handed down by blighted neurotics of the sort who write constitutions.

Atlanta had a 12-gauge sawed-off shotgun and a box of shells smuggled in inside a cake. In Arizona recently a man's son broke him out at gunpoint. In Lewisburg, I checked a book out of the prison library that gave specific instructions on smuggling things into the prison, including, but not limited to, sawing wooden chess pieces in half and secreting bullets in hollowed out sections and gluing them back together and mailing the chess set into the prison, sewing green money, narcotics, blades, and other goodies inside hardcover book bindings, and switching shoelaces containing gigli saws in the visiting room. A gigli saw is flexible and so slim, it can be hidden inside a shoelace and so strong it is used to cut steel in half. The best "home delivery" I heard of never came off but if it had the country would have seen it on TV and in the newspapers.

The idea was to have an outside accomplice Piper Cub with a smoke attachment for the exhaust (see Poor Man's James Bond) directly over the exercise yard. With the plane billowing smoke the tower guards would think the plane was going to crash directly into the prison and be running for lower ground. Nobody wants to be in a tower an airplane is about to crash into. Once the plane cleared the prison walls and was over the exercise yard the pilot was to kick out a bundle of pistols, gear to scale the walls, and whatever other goodies were obtainable (such as land anti-tank weapons, etc.). In the confusion and smoke the convicts

would go over or through the walls. A similar operation took place in Terre Haute in a heavy fog one morning. 400 men walked out to the prison industry to go to work and 18 of them just kept walking. Three of them had wire cutters in their pockets and simply cut their way through the chicken wire fence surrounding the prison. One walked half a mile to the Wabash river, plopped himself on a floating log, and had a leisurely breakfast in Louisville, Kentucky the next morning.

Two "weapons" more deadly than all the others put together also need mentioning. One is money. The other is the human mind. For enough money anyone—up to and including the warden—can be "taken out". At one time the Mafia ran Lewisburg by greasing the prison personnel and muscleing the other convicts (who could they complain to?). I used to watch them kiss each other on the cheeks when a busload got shipped out (and almost had a heart attack when a guy at a mess hall table with me asked loud enough for everyone to hear, "are those guys queer?").

But the human mind has to be the deadliest. With a gun, a knife, or a bomb your options are limited. There are only certain ways they can be used. Money is more flexible but there are still limitations. Lately a flap came up about letting certain types of books into the prisons—as if convicts couldn't acquire the information any other way. What nonsense. All the ACLU

tried to do in their recent court case regarding reading material was make a simple operation simpler. Any time any of us wanted a "forbidden" book we simply had someone on the outside take off the covers and replace them with something like "freshman geometry" or "English essay writing". A good many of the guards were functional illiterates and never checked anything but the covers anyway. Whatever it was we wanted, we could think of some way to get it. Some guys even got women into the prison, serviced them, and sent them on their way. Unfortunately, the warden caught two couples banging away in the Officer's Mess kitchen one day and things got tightened up for awhile. I don't know how many copies of the Poor Man's James Bond and other bomb books were circulating when I was in, but it was a bunch.

Finally, there seems to be some concern about the type of criminal who might get ahold of certain books. Most federal criminals are usually doing time for white collar crime, bank robbery, or large-scale narcotics operations, "thinking man's" crime that requires careful preparation and foresight. Besides which the FBI depends so heavily on informers (95% of their convictions are obtained through snitches) that all they salt away are the dumb, the careless (like myself), and the clumsy. The REAL crooks are not locked up. Your Congressman can buy any book he wants.

State criminals are somewhat more erratic but the really nasty ones are usually kept in isolation (where the materials for mayhem are simply not available) for their own protection. A child molester is likely to meet his end in a general population for two reasons: he won't have any friends

which in turn makes him prey for any disgruntled convict with a knife. That doesn't happen with normal convicts. The last time a yo-yo in Terre Haute ran his mouth at a friend of mine, three of us fell out on the yard to lend a hand—and at 6'2" and 220 lbs. I was the smallest of the three. The mouth runner never showed.

Why our state and local governments keep funding prison systems is a mystery to me. The horsewhip and the executioner would be cheaper and far more effective. What prisons do is accentuate, heighten, and sophisticate whatever qualities a man has—for good or evil. Germany locked up a somewhat unco-ordinated street agitator in Landberg Prison in 1923 and in 1925 disgorged a real sophisticate: Adolf Hitler.

Is our next Hitler in our prisons? Or is he out and is it already too late?

BUILD A HOMEMADE CANNON

By Kurt Saxon

With a few dollars and a little work, a Survivalist can make any number of cannons accommodating a pound or more of black powder and shooting chain, scrap metal, etc., causing disaster to any group of marauders.

The basis of the homemade cannon is the Fougasse. (See page 104 of THE POOR MAN'S JAMES BOND). This merely consists of a three to six inch wide plumbing pipe threaded for a cap. You can buy such pipe from any plumbing supply shop or most hardware stores.

Three to five feet would make a good cannon, depending on your choice.

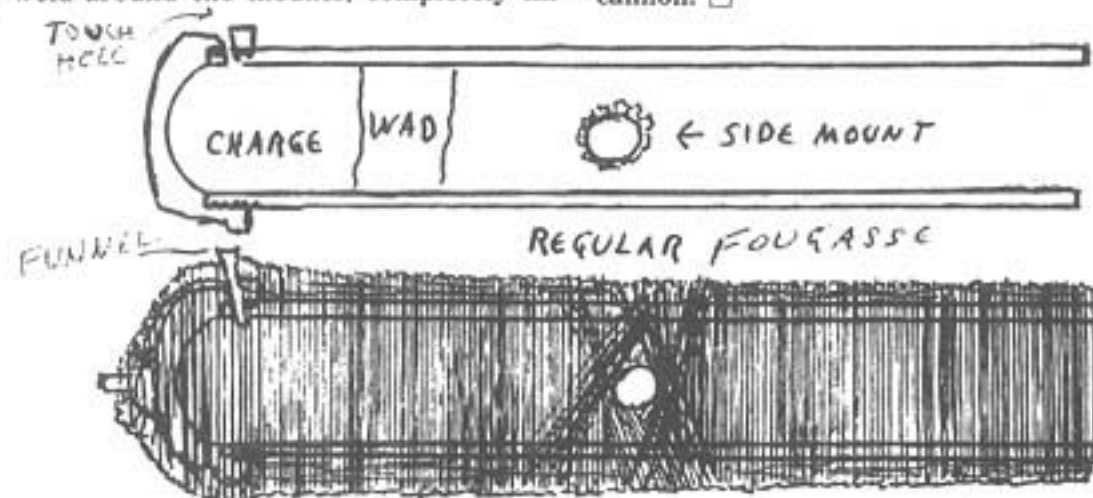
The plain pipe and cap would pack a great wallop. First weld two six inch long by two inch wide steel rods about midpoint from the rear of the cannon. This is to hold the cannon on the mount.

Then drill a one-eighth inch hole down through the cap and into the barrel. This is for the fuse. With the charge poured in and tamped with wadding, you can just pour powder in the touch-hole, eliminating the need for a fuse.

If you want a more powerful cannon, weld an inch long rod of 1/2 inch steel onto the cap. Bore the touch-hole large enough to accommodate a length of copper gas line from a car. Ream the end of the gas line to make it like a funnel. Wind a couple of hundred yards of fence wire tightly and neatly around the cap, funnel and side mounts. To start, weld the end of the wire to the bar right next to the cap.

When the winding is an inch or more thick, weld the end of the wire to hold it down. You might put about four lines of welding from the cap to the barrel to keep

the wiring permanently in place. Also, weld around the mounts, completely fill-



ing up any loose spaces lest the mounts become areas of weak points in the barrel.

Such a cannon could probably accommodate a steel ball or other inside diameter missile.

I'd use a long fuse to test any such cannon. □



THE AIMPOINT Electronic Sight puts a red dot of light on the target, eliminating the need to line up two elements, as in using iron sights. Using the Aimpoint is thus easier and quicker, say its makers. The sight uses its own light, making it easier to shoot dimly lit targets, its makers claim. The dot covers a three inch circle at 110 yards and about half that at 55 yards. The lightweight alloy device uses standard Weaver scope mounts. Power for the light is provided by two batteries, with a life of from 500 to 1,000 hours. The list price is \$149.95. For information: Aimpoint USA, 29351 Stonecrest Rd., Rancho Palos Verdes, Calif. 90274.



Now you can shoot THE NEW American FLAT BOW

By JACK HAZZARD

Popular Science Monthly, August 1936

WHEN the white man provided the American Indian with a cheap trade musket in place of his native bow and arrow, he saved himself a good deal of grief, for had the red man developed his weapon along a logical path he might have arrived at an approximation of the bow we now know as the "semi-Indian," "flat," or "American" bow. With such a bow he could have shot with accuracy at a hundred yards (about the extreme accurate range of the long rifle), and could have delivered arrows faster than any frontier scout could load his rifle.

Any home workman, equipped with ordinary tools, can readily build the most modern and most efficient bow yet designed. The best material for the amateur is the imported wood known as "lemonwood." It can be worked almost entirely by measurement, without much regard to the grain. California yew and Osage orange probably make a better bow, but not for the inexperienced builder.

Lemonwood can be had from most dealers in archery supplies, either in the rough stave or cut to approximate outline. The price ranges from about \$1.75 to \$3. In ordering you should be careful to say you need a wide stave for a flat bow.

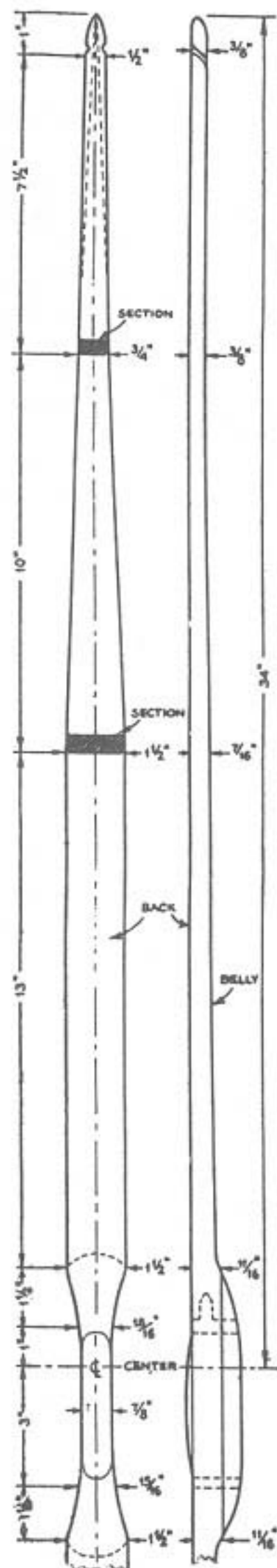
The dimensions given are for a bow 5 ft. 8 in. long with a weight (the archer's term for the strength of a bow) of from 45 to 50 lb. at a draw of from 27 to 28 in. This combination is suitable for the average man. When new the bow will draw 5 lb. or more above these figures. For clearness, only the upper limb of the bow is shown on the drawings. The lower limb is similar but slightly stronger. It should be $7/16$ by $1\frac{1}{2}$ in. at a point $14\frac{1}{4}$ in. below the center line; $3/8$ by $3/4$ in. at a point $24\frac{3}{4}$ in. below the center; and $3/8$ by $9/16$ in. (instead of $3/8$ by $1/2$ in.) at a point 1 in. from the very end.

The stave, as it comes from the dealer, has been shellacked or varnished to prevent checking. Remove this coating from the back—the side away from the archer as the bow is held in position to shoot. Plane and sandpaper the wood just enough to provide a smooth surface. Stretch a fine piece of unkninked copper wire tightly down the center line of the stave, mark dots at regular intervals, and connect the dots, using a long T-square or other straightedge and a sharp, hard pencil.

Lay out cross lines as shown on the drawing and mark the widths by dots. Connect these dots with straight lines, giving a rough idea of the back of the bow. Since the sharp shoulders and angles are unsightly, change them free-hand to graceful curves along one side, then trace paper templates in order to reproduce the curves on the opposite side.

With drawknife, spokeshave, and finally a pocketknife or scraper and garnet paper, work to the lines marked on the back, keeping the cuts at right angles to the surface of the back.

Run straight lines along the edges of the stave from the center



out to the tips to mark the thickness of the bow, following the dimensions on the drawing: Both edges of the stave should be marked. Now mark the profile of the riser at the grip, dipping it boldly into the run of the belly at each side of the handle. If the stave did not come with a piece glued on to form the handle, you will, of course, have to cut a suitable block of hardwood about $\frac{1}{2}$ by 1 by 8 in. and glue it on.

Set the bow in the vise, belly up, and shave off the wood above the lines just drawn. For the deeper part of the cut near the tips, a drawknife may be used with caution; but nearer the handle where the cut is shallow, a spokeshave and small block plane are safer. When the bow has been worked to a rectangular cross section over its whole length, except at the riser, which is rounded, you are ready to test it for curve.

This work has probably consumed an evening, and you are obliged to lay the bow away until you have more spare time. Before you do so, rub the whole bow with shellac to prevent any possible checking or absorption of water.

You now need what is known as a "tiller" for testing the bow, as well as a temporary or working bowstring and a shooting tab for protecting the fingers. The tiller is a piece of scrap wood about $\frac{3}{8}$ by 3 by 30 in., notched at 2- or 3-in. intervals as shown to catch the bowstring and notched at one end to fit over the handle of the bow. As the tiller may be used later on the finished handle, it is just as well to pad the end jaw with leather.

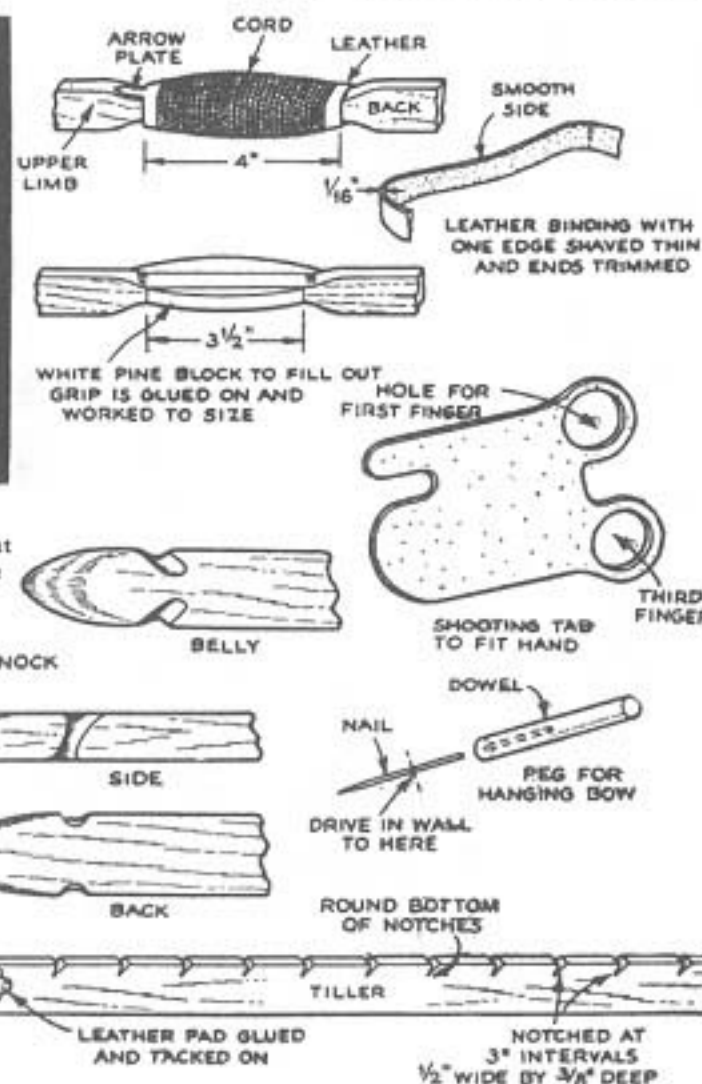
The tiller serves to hold the bow bent for inspection during construction and, as it will be used often, should be carefully and accurately made.

The string for tillering must be far stronger than the one ultimately used for shooting—at least 60 strands of No. 20 linen thread. Lay up twenty strands 18 in. longer than the bow, stretch them smoothly, and wax them together. Make two more sets and tie the three together. With the tied ends over a hook twist each of the three groups of thread individually to the right and have an assistant hold the twist in. Now take all three and lay them round each other to the left, as if making rope. The right-hand twist makes them grip one another and cling together. Put the string under tension and rub thoroughly with beeswax. Work it round and compact by rubbing with a small piece of leather held between the fingers. Tie a permanent loop (bowline) at one end and use a timber hitch to fasten the lower end to the bow.

Later you will need a shooting string, and because



Using an old T-square to mark the lines showing the height of the belly of the bow. The vise is faced with removable wooden jaws



At left are the back and side views of the upper limb and handle of the flat bow. Above are sketches showing how the handle and nocks are finished and how a shooting tab, tiller, and peg are made

a breaking string endangers not only the bow but the archer and bystanders as well, it is better for a beginner to buy a few strings. When one of these becomes frayed, take it apart, study the make-up, read a bit on the subject, and try to make one yourself. You will soon be able to produce a creditable string.

The notches at the ends of the bow, or "nocks" as an archer calls them, are best put in with a small round file. At the side, near the back, the nocks are half round, slanting across the side toward the grip and flaring slightly to give room for the string to change direction as the bow is drawn. They should not extend across the back of the bow as this would seriously weaken the bow tip.

Slip the loop down over the upper tip, draw the string down the bow, and fasten it at the lower nock with a timber hitch. Have the string about 3 in. shorter than the distance from nock to nock.



Bows are among the oldest weapons in the world, yet an amazing thing was only recently discovered about them. Through mathematical analysis, laboratory investigation, high-speed photography, and painstaking field tests, it was found that the famous English long bow, after which practically all target bows are patterned, does not have the most efficient shape. Its beautifully rounded limbs are a delight to the eye, but the best cross section for a bow is something much simpler—just a plain rectangle. This discovery led to the development of the modern American flat bow, one easily made variety of which is described here.



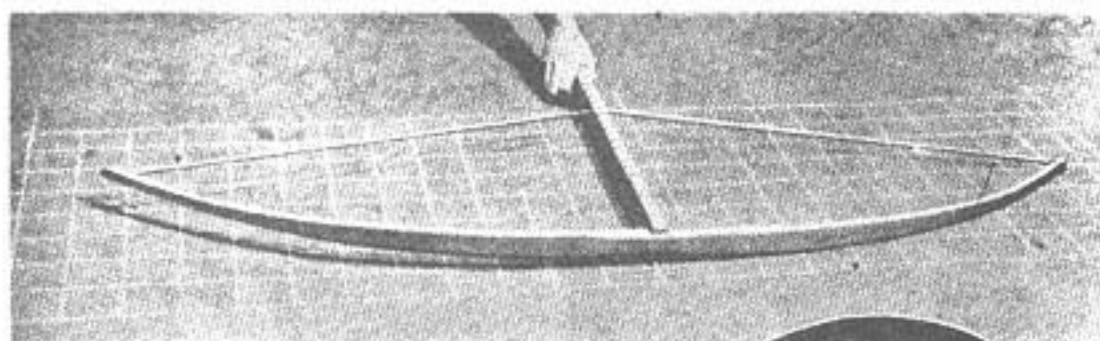
Place the bow in the vise and have an assistant pull carefully on the lower tip while you pull the upper and slip the loop in place in the nock. Do not push on the limbs, for a breaking bow nearly always throws splinters forward with murderous force. The string is likely to stretch considerably, and you will have to adjust the timber hitch several times before you hold the bow bent to any great depth.

As soon as you have a bend of some 5 or 6 in. in the bow, place the tiller on the handle and hold the bow, back down, on the floor, steadying it with your toes. Then pull the string up a few notches on the tiller with both hands. Have your assistant ready with a piece of chalk to mark any section which does not bend evenly, for the whole bow must contribute to the shot if you are to obtain the utmost efficiency.

Let the bow down, unbrace it—that is, slip the loop out of the upper nock—and replace in the vise for scraping at the spots marked by the chalk. To make sure that the whole section is reduced evenly, rub the part to be scraped with soft pencil lead. By scraping the marks away, you remove a thin layer of wood and will not risk reducing one side more than the other.

Flat bows bend in a different arc than ordinary long bows—practically a perfect arc, slightly flattened in the center opposite the grip. So slight is this flattening that the radius of the curve of each limb should be the same as the length of the draw—in this case 28 in. If a template like that on the following page is laid on the floor and the bow worked down carefully until it fits neatly within the arcs, you are practically sure to produce a bow which will give flat trajectory, good distance, and little jar. Do not keep the bow at full draw more than a few seconds at a time.

Generally speaking, the bend should show first in the center of the limbs, then in toward the grip, and lastly in the third of the



Testing the curve of the tillered bow on a grid-iron chalked on the floor. In circle: Using a spokeshave to cut the belly down to guide lines



Slight reductions are made with the blade of a penknife or a steel scraper. The wood is first marked with soft pencil so no spots will be overlooked

Especially care and delicacy are required in trimming down the tips or ends of the limbs where the bow is narrow. The best safeguard is to test the bend frequently by using the tiller

limbs nearest the tips. Allowing the tips to bend too early in the work weakens them excessively and produces what are known as "whip ends."

Finally the corners of the limbs are rounded slightly to lessen the danger of denting. Draw a line $1/16$ in. each side of the back corners and $3/32$ in. from the belly corners and round only to these lines. Sand with No. 6/0 garnet paper until fairly smooth and rub on a good coat of shellac.

The bow is now ready to shoot for the first time. Although it is not essential, my own practice in breaking in a new bow is to select arrows considerably heavier than those to be used later. If heavy arrows are available, use them for about 200 shots, as this works the bow down without permitting it to recoil too sharply. Birch hunting arrows $3/8$ in. in diameter are about the right weight for this purpose; otherwise use cheap birch target arrows. They can be obtained from archery dealers or sporting goods stores for so little that it hardly pays to attempt to make them. Besides the shooting tab to protect the fingers, an arm guard or "bracer" is needed to prevent the bowstring from bruising the left forearm. The conventional bracer is made of heavy leather, but a piece of fiber or thin, narrow strip of hardwood may be tied on to serve the purpose.

Now tiller the bow again. It will have lost weight and changed shape slightly, and will need further correction.

Glue on a thin piece of white pine to round out the back of the bow. Taper it in gracefully to meet the back of the bow, and round it into the sides. A serviceable grip is made by serving the bow with crab line, chalk line, or braided trolling line. The total length of the



grip should be about 4 in., the winding occupying $3/4$ in. of this space and the balance being covered by leather circlets. The upper circlet has a projection at the left of the bow; this serves as an arrow plate and prevents arrows from wearing the wood as they leave the bow. Use rather thick leather so it may be whittled away from the underside to a thickness equal to the string binding. The outer edge is trimmed to a feather edge and the ends thinned to make a neat joint; then the leather is dampened, glue coated, and bound in place with narrow strips of cloth until dry. As soon as the leather is dry, shellac the whole handle. The cord may then be painted as suits the bowyer's fancy, and another coat of shellac applied to protect the color.

Plush, velvet, leather, and gimp braid are also used to pad handles, but cord affords a firm grip and is very durable.

Once the new bow has been well tested and has proved itself satisfactory it should be cleaned carefully. Remove all tool marks and thoroughly sand it with the finest garnet paper. Thin some white shellac about fifty percent with alcohol, turn a little on a soft, lintless cotton cloth, and rub the bow briskly until the shellac has dried and a surface begins to show. It will be necessary to work a short section at a time and to go over the whole bow several times to build up a shellac surface. Smooth lightly with very fine paper or steel wool and rub with furniture or piano polish until a dull gloss finish results. This method builds up a surface so thin that it will not crack with bending, yet thoroughly water resistant and beautiful to the eye. A bow carefully waxed and polished after each field day soon takes on a fine luster, and the surface becomes toughened.

If, after a month or so of regular shooting, the bow is found too strong for comfort, it can be reduced to suit and refinished.

So far as the making of various types of arrows, bowstrings, bracers, quivers, targets, and other archery tackle is concerned, there are several excellent handbooks and a variety of booklets that give detailed information.

Keep the bow unbraced when not in use. Hang it from a peg or lay it on a shelf or



Wrapping the grip with crab line. The line is clove-hitched to a convenient nail or hook

across a pair of pegs supporting the middle third of the bow. A good bow rack can be made by driving sharp-pointed finishing nails from which the heads have been clipped part way into a plaster wall and slipping over them dowels in which a hole has been bored. The holes in the dowels should be a close fit. If the nails are driven at a slight upward angle and the dowels are cut to fit the wall closely, the effect will be that of wooden pins set in the plaster. If the nails alone were used, the iron would corrode and leave unsightly marks on the bow.

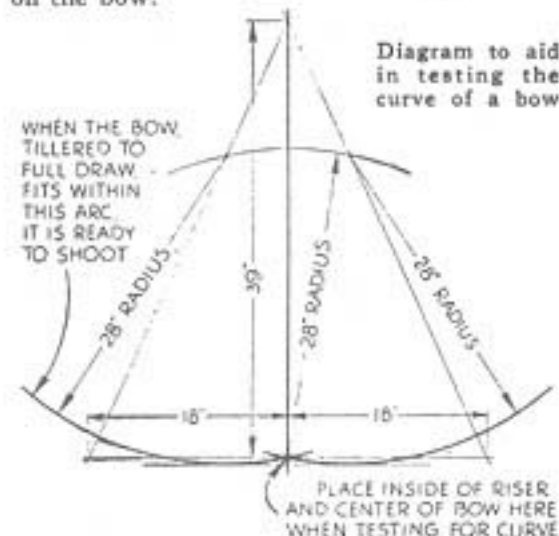
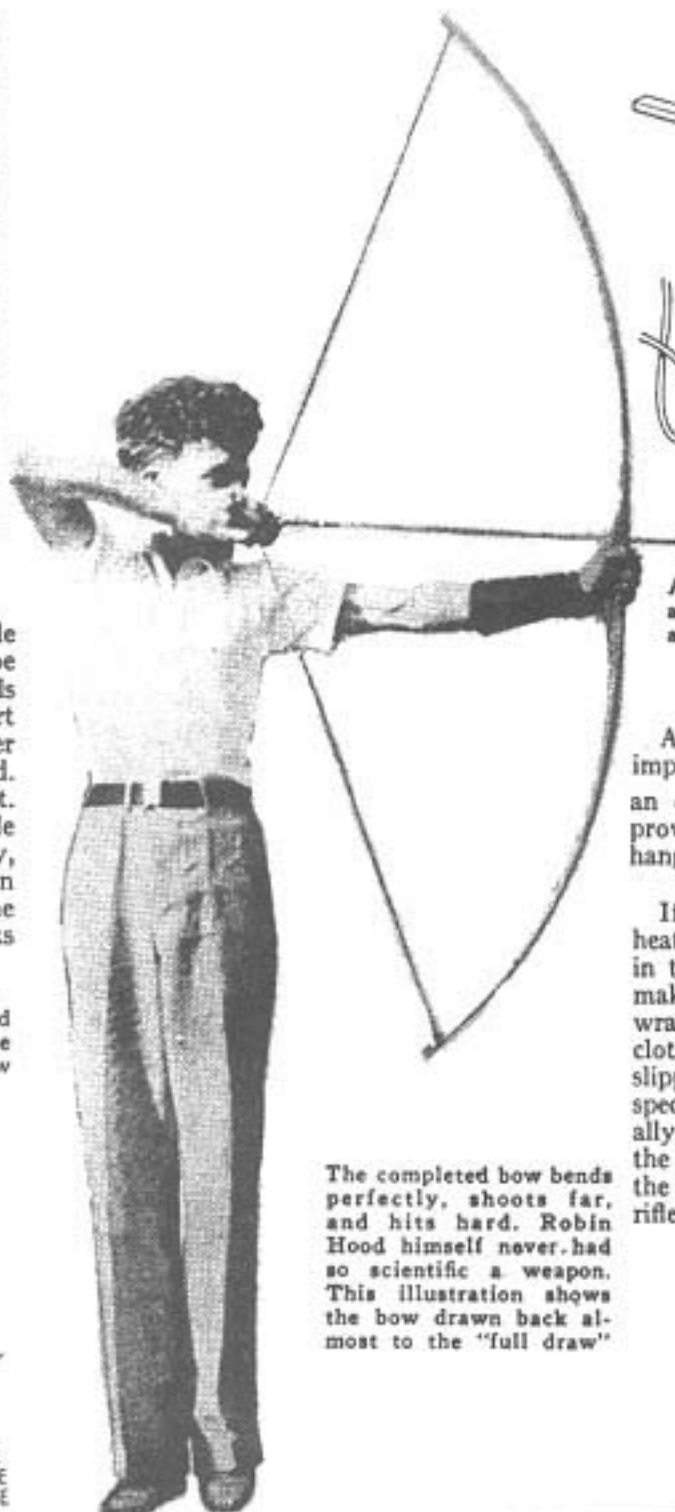
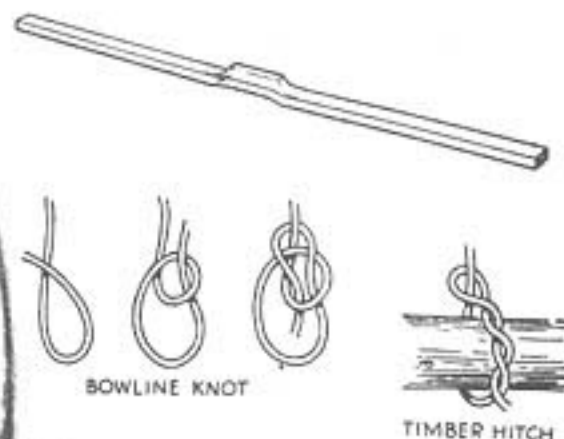


Diagram to aid in testing the curve of a bow



The completed bow bends perfectly, shoots far, and hits hard. Robin Hood himself never had so scientific a weapon. This illustration shows the bow drawn back almost to the "full draw"



A flat bow stave with handle riser glued on, as purchased from dealer; and the knots used at upper and lower ends of the bowstring

A shelf, too narrow to accumulate other impedimenta and with a raised edge, makes an excellent place to lay a bow. It can be provided with a backboard bearing pegs for hanging other archery supplies.

If you must keep your bow in a steam-heated apartment during the winter, place it in the coolest dry room. Hot, dry heat soon makes a bow brittle. When storing the bow, wrap it from end to end in a strip of woolen cloth, such as an old spiral legging before slipping it into a bow case. It should be inspected from time to time, warmed occasionally, and strung and bent at intervals during the off season. In short, it should have about the same consideration that you give your rifle or your golf equipment.



THE DEADLY FOUGASSE

By A.D. Cranford

Some people have a misconception about crowd control. Several have written **THE SURVIVOR** asking about recoilless rifles, muzzel loading cannon, and sophisticated methods of employing explosives. Really, the best device for such work is the Claymore mine or the fougasse. Since the average survivalist has trouble getting military equipment such as Claymore mines, the text presented here will show how to make and employ the fougasse.

The fougasse is simple to build, it costs little to manufacture in comparison with other devices used for the same job (even a survivalist needs to choose cost effective weapons), it uses low-order explosives

such as gunpowder (which saves valuable high-order explosives for other duties) and is easy to emplace; yet it is a very effective weapon that can take care of most of the chores people want artillery for. Properly loaded, it can kill humans to 200 yards or motor vehicles to 50 yards.

You will need the following to construct your fougasse:

Iron pipe, approximately 3 feet long and 2 to 4 inches in diameter. The pipe cannot have cracks or flaws, but other materials can be used with varying effects.

1/2 pound of a low explosive, such as gunpowder. This is the propellant charge.

2 plastic bags.

Electrical igniter, either improvised or

commercial.

One pound of small stones, scrap metal, broken glass or whatever your little heart desires; this is the part thrown at the enemy by the propellant charge.

A can of plastic auto-body filler.

Rags for wadding.

A firing circuit consisting of a battery, a switch, and enough wire to run between the position it is controlled from and the device.

A non-metallic stick.

And, some string or rubber bands.

Procedure: 1) Pack two to four inches of auto-body filler, depending upon the diameter of the pipe, at one end of the pipe, following the directions on the can, and let it dry thoroughly (if a threaded cap to fit an end—also threaded—of the pipe is available, these can be used. Simply screw the cap on one end.) Barring electronics,

the fresh plastic auto body filler can be pierced with a wire and a plastic coated fuse can be pushed through to the explosive charge before the filler sets.

2) Place the propellant charge and the igniter in one of the plastic bags, letting the firing leads hang out of the package. Tie the top of the bag closed with a rubber band or piece of string.

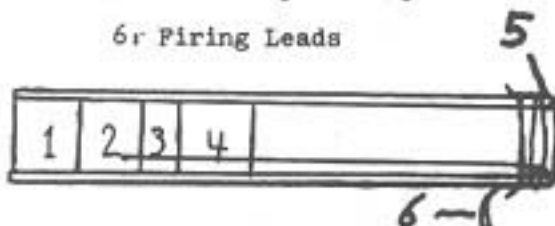
3) Connect the firing leads to a piece of twin wire, such as TV wire. Insert the package into the open end of the pipe. Shove the wad in the pipe over the packaged charge and carefully pack tightly with the stick.

5) Pour in the pound of projectiles and put another wad like the first one on top of the whole load. Again, pack very carefully, but as tight as you can.

6) Fit the remaining plastic bag over the muzzle of the pipe. Be sure the firing wire is sticking out, and tie a string or rubber band around it to hold the bag in place. This weatherproofs the weapon. It should look something like the illustration when completed.

Now your fougasse is ready to emplace. Before you emplace it, you must pick a

- 1: Plug of filler
- 2: Propellant charge
- 3: rag wads
- 4: Shot charge
- 5: Weather-proof cap
- 6: Firing Leads



spot to take full advantage of its character.

First look at the area to be defended and decide where you would bring an attack force. Then site the fougasse to enfilade that route. Enfilading a target consists of hitting it lengthwise. By doing this, you can hit most of the personnel in the path. If you think more firepower is needed, make another and site that one so their blasts cross each other. Try to get the line of fire parallel with the ground, as you neither want to shoot over an enemy's head nor merely dig a nice hole for it to

hide in.

Now bring your fougasse and lay it on the ground, sight along the barrel, and line it up. At this point you can merely hook up the firing circuit, but you will get better performance if you firmly anchor the thing to the ground or something solid.

Also, you should camouflage the device. Just make the weapon look like some harmless object, conceal it, etc. Most of the time it is buried with the open end out—this both anchors it and conceals it, and further strengthens the pipe wall, and again improves performance of the weapon.

You can rig this up so the enemy will inadvertently fire it, or you can use a command detonation (remote control) system. The command detonation is recommended for an occupied position. To help eliminate embarrassing misses, either use a marker or pick out a marker already there and when the foe looks about level with it, push "the button."

Install the battery and switch where you intend to conduct the defense from. That is all there is to putting this weapon together.

SCOPES FOR SURVIVALISTS

By David Walker

Nothing you can improvise will help your shooting as much as a good scope. It will give you range and accuracy beyond anything else in your battery. Imagine being pinned down by a sniper 300 yards away and all you have is a bow or muzzleloader to defend your refuge. The majority of today's rifles are drilled and tapped for scopes because the accuracy potential of most cartridges is beyond the range of the open sights supplied on the gun as it comes from the factory.

The selection of scopes is overwhelming and the novice should know a few things before he buys, so he will get the scope that will best fit his needs and circumstances. Some factors to consider are: 1. The terrain where you expect to do most of your shooting. 2. The anticipated range you will shoot from. 3. The weapon and cartridge you will use. 4. What or who you expect to be shooting at. There are some other factors such as lighting conditions, that will be covered later on.

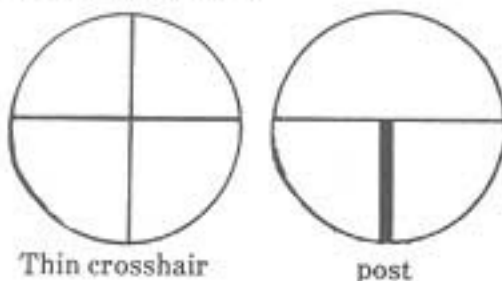
The power of a scope is determined by a number. For example 4x means the image will be magnified 4 times at a given distance. Lower powered scopes will have a greater field of view than a high powered one. Unless you expect to be shooting at very long range, I would stick to a lower power. In wooded areas a 2 to 3x power scope would be a good choice.

The wider view will aid you in picking out target in the brush. If you live in a flat open area a 6x to 9x power scope would be about right. Higher powered scopes are more difficult to hold steady on the target so use a rest if possible.

Variable scopes have become very popular and in my opinion for good reason. Versatility. You never know under what conditions you might need your rifle when you are living self sufficiently. Variable scopes enable you to change the power by merely turning the power ring. 2x-7x or 3x-9x are both good choices in a variable.

Critics of variables say they are fragile, expensive and cause the point of impact to shift when the power is changed. While they do cost more, to me the difference is worth it. I have not noticed that accuracy was affected by changing power and if you take care of your scope you should get a lifetime of use from it. If you only have one rifle a variable is your best bet.

Most brands of scopes have a variety of reticles to choose from.



The thin crosshair is the most precise but is hard to see in thick brush or poor light. Personally, I like the post.

There are countless brands of scopes. Three of the best are Leupold, Redfield, and Weaver. All are good quality, have wide selections and give their moneysworth.

You will need to buy mounts for your scope. Different rifles will use different mounts but your gun shop should have a selection for all common makes on hand. The mounts consist of two items. Bases, which hold the rings. And rings, which hold the scope. I prefer Weaver mounts.

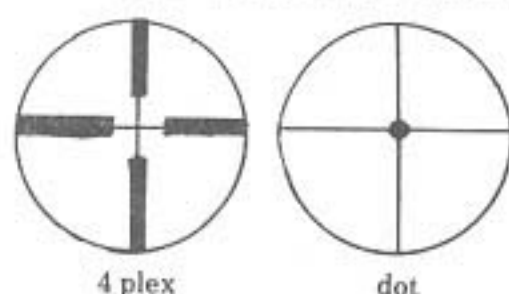
Once you have your scope mounted you have to sight it in. It is difficult for many people but it needn't be. Sighting in is firing shots at a target and adjusting the windage and elevation of the scope until the flight of the bullet coincides with the sight picture of the scope. If your shots are so far off the mark you cannot adjust the scope to get them on the bullseye, you will have to shim the mounts. Shimming is placing small pieces of paper or plastic between the scope and mount. This will move the sight picture, depending on how you shim it, enough to get it on target where you can then fine-tune it with the windage and elevation dials.

A good way to sight in a bolt action rifle inside the house without shooting is: 1. Put a target on the wall on the other side of the room. 2. Take the bolt out of the rifle. 3. Use a rest to put the rifle on. You can improvise with a footstool or coffee table. Anything that

you can put the gun on and hold it perfectly still.

Look through the bore of the rifle and line it up with the bullseye on the target. Now hold it still and look up through the scope. If it also is lined up to the bullseye you're all set. If not adjust the scope until it is. This will save you ammo and if done right will be close enough so you should only have to fine-tune it at the firing range. Remember that the weight and brand of you ammo are apt to vary on their point of impact. 150 grain Remington will not shoot exactly like 180 grain Winchester for example. So check and adjust your scope accordingly.

Scopes are of little use in the dark. Some models use a battery-powered dot of light but this is not the best solution for the Survivalist and the lens of most scopes do not adapt to poor light as well as your eyes do. The Army uses starlight scopes but these are extremely expensive, very difficult to obtain, fragile, and difficult to mount because of their size. I feel the best sighting device available to the average person for use in poor light, is the Weaver Qwik Point. It is sighted in like a scope, and though it does not magnify the target it throws a fluorescent orange dot of light. Where the dot is, is where the bullet will strike. It is ideal for use in heavy brush or



poor weather and is extremely fast.

It is far better than point shooting in the dark. Qwik Point is also available for shotguns, a good idea since many people cannot afford several rifles and you'd only be using it at close range anyway. It uses

Throwing Knives at Target Is Novel Sport

Popular Science 1933



Each contestant throws three knives at a time and adds up the points.

KNIFE throwing is an inexpensive, exciting game of skill in which all ages and both sexes can participate. It has something of the novelty and thrill of the circus and never gets monotonous. The equipment can be set up in the cellar in an evening. It consists of an old chopping block, three knives (ours cost 19 cents each), a small roll of tire tape, rag bags, two boards, nails, and a little paint. The total cost is less than a dollar.

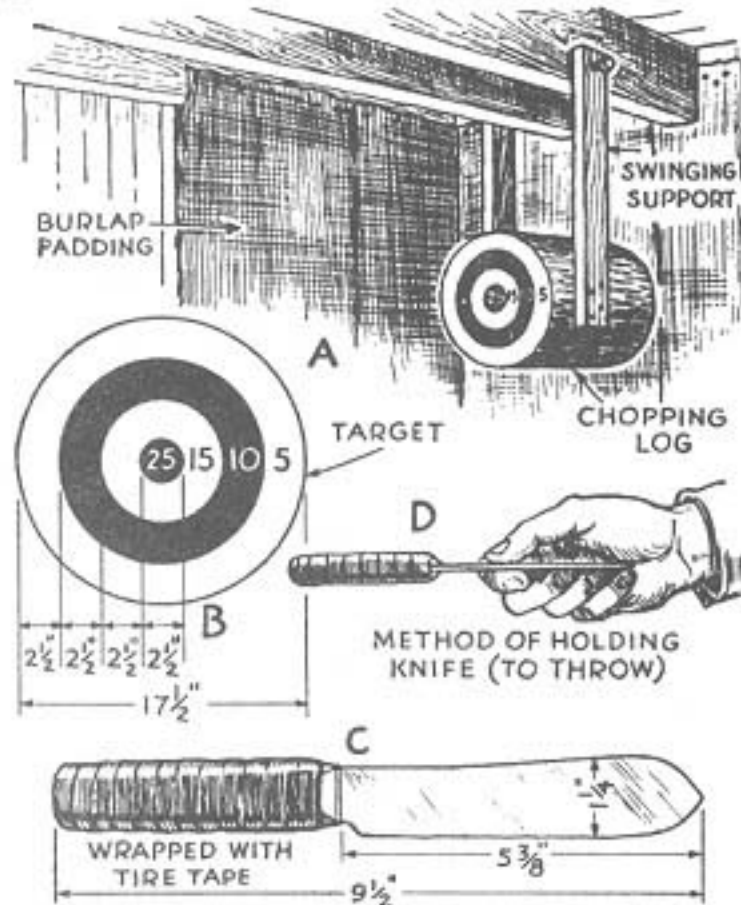
The target *A* is a block of wood without knots, 17½ in. in diameter and about 15 in. long. Soft pine is best. Saw the face smooth across grain so that knives can enter with the grain. Paint rings as shown at *B*. Attach a board midway from each end on either side, and hang on joists about 52 in. from the floor in such a way that the block can swing back and forth.

About 1 ft. behind and, if necessary, to the left and right, tack up rag bags to stop knives and prevent their damage.

Lay rough boards loosely on the cement floor, under and in front of target. Cover these with rag bags or old carpets.

An ordinary butcher's knife will serve the purpose. Grind to the shape shown at *C* for balance, and wrap the handle with tire tape to hold the rivets. Grind and round off the cutting edge up to within about ½ in. of the point and file the point to a blunt, chisel-like edge that is not sharp enough at any place to cut the hand. This is important. Experience has shown that although this makes the game safe, it does not interfere with the penetration of the knife. Not one of all who have thrown these knives has ever received even the slightest injury.

The position of the knife in the right hand is shown at *D*. This gives a firm,



How the target and knives are prepared. The blades are well blunted so that there is no danger of getting a cut

steady grip. Stand facing the target 12 ft. from it, knife in hand. With arm over head, elbow bent slightly, swing arm at shoulder forward and downward.

After throwing three knives, we count score, remove them from target or floor, and throw them again until we have thrown 21 knives in 7 sets of 3 each. The accumulated total thus gained is our score. A doubtful knife in the target is measured across its width at the surface of the target. The greatest width in either ring decides the issue, and one exactly half and half is counted on the lower score. Only knives in the target after the third has been thrown are counted. Variations in knives, knife holds, distance from target, and other conditions will quickly suggest themselves.—W. W.

HOMEMADE SMOKE BOMBS

by Kevin Christopher

For some reason, smoke bombs hold a special place in my heart. Nothing can bring on as much confusion or panic and is so safe, simple and fun to make.

A good smoke bomb filler is a seven-to-six volume mix of potassium nitrate and sugar, respectively. This can be used as is, in powder form, or it can be poured into a soda or beer can and, with a cut straw covering the fuse, can be carried in the open all day.

Another good filler is a seven-three-three volume mix of potassium nitrate, sulphur and regular household flour, respectively.

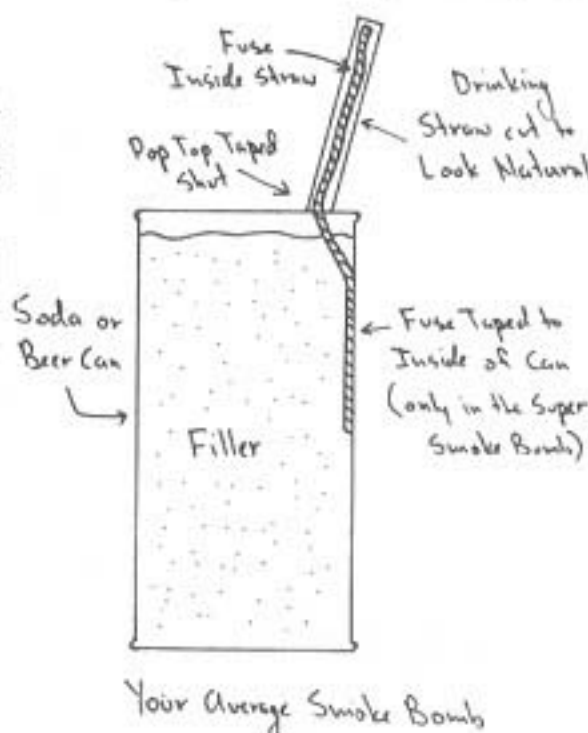
Both of these mixtures produce flame and great heat and are a little frightening to look at. The flame can be suppressed if you add a little table salt to the mix. Another chemical which suppresses the flame is ammonium chloride (sal ammoniac) and it has the added advantage of increasing the smoke output. But, take care when adding these suppressants because too much will kill the reaction completely. I really haven't done much with this flame suppression thing so I can't tell you how much to add to be effective.

As I said, a good container for these mixtures is a soda or beer can with a pop-top lid. Of course, you can use them as a powder, but they're a little difficult to light. The best way to light a powder on a flat surface with a match is to plunge the match into the powder while the head itself is still burning. Match heads are potassium chlorate mixtures and generate quite a bit of heat; enough to light most mixtures.

If you want to make a nifty, canister-type smoke bomb, you'll need a pop or beer can with a pop-top lid. Wash the can out and let it dry. Then, using a paper funnel, just pour your chosen filler in through the pop-top. Stick in a fuse and tape the can shut. If you want to walk around with the thing in your hand and not be noticed, then use clear scotch tape and cover the fuse with a drinking straw cut so that the smoke bomb looks like a can of soda with a straw in it. (This is one reason that I prefer a soda can. A drinking straw looks just a little stupid in a beer can. Also, you can take a soda can more places without hassles because it's non-alcoholic).

If you're the domestic type, then you'll want to make a Super Smoke Bomb. This kind puts out the most smoke of all but is, of course, the most difficult to make.

You'll need another clean and dry soda or beer can with a pop-top lid. Take off its bottom so you have a nice, clean cut. In



other words, you want the bottom of the can to be a perfectly circular piece that fits snugly into the can. Use an electric can opener. Anyway, stick a fuse through the pop-top and tape it to the inside of the can with flammable tape (you can use scotch tape). Also, cover the rest of the pop-top with tape and you're ready for the next step.

Now, get a hot plate and take it outside. Do not do the following indoors! Put two cups of sugar in a cheap pan, place it on the hot plate and wait for the sugar to melt. Watch it constantly to make sure it doesn't begin to bubble. If it does, stir for a little while. When there gets to be more molten sugar than solid sugar, stir continually until all the lumps are gone. If the sugar begins to bubble, steam or turn black, remove from the heat. When it all has melted, turn the hot plate to "low" if it's adjustable. If not, remove from the heat.

Slowly, a little at a time and with constant stirring, add two-and-one-third cups of potassium nitrate (at this moment, the mixture is very flammable, almost explosive, and so is dangerous. Be careful). As you add the nitrate, the goop will thicken considerably. If it gets too difficult to stir, you can heat to thin it out a little, but take care as too much heat will cause the goop to ignite. Keep a hose or a bucket of water around just in case, wear goggles and never put your face, hand or anything else you might need later over the pan!

When all the nitrate has been added and the mix has been well-stirred, scoop it out into the can you made earlier and level the goop out so that the bottom of the can looks natural when put over it. Let the

stuff cool for about an hour and glue or tape the bottom on. If you use glue, use a non-water-based glue because water all but destroys this mix. If you tape and want to carry the thing around, use scotch tape as described earlier.

By the way, I call the potassium nitrate-sugar goop you just made "The All-Star Flaming Peanut Brittle." If you really want to get ridiculous, make about ten times as much and scoop it into a three-pound coffee can. Wow!

All these smoke bombs produce terrific heat and usually melt the can in which they're contained. This can be a blessing or a curse. On one hand, the heat keeps anyone from picking the bomb up and chucking it out a window, but they can also cause fires which can kill people. This is not good so judge yourself accordingly.

Though I call these smoke bombs, they have other uses. They produce a large, luminous flame, lots of noise and, of course, large volumes of smoke. In short, they make their presence known. So they can be used to distract people or as incendiaries.

If I were to judge these smoke bombs in terms of their smoke output, the order from worst to best would be: potassium nitrate-sugar; potassium nitrate-sulphur-flour; and the Super Smoke Bomb.

THE FANTASTIC FEINWERKBAU

The first offer in Mel Tappan's PS Letter is the Feinwerkbau 124 air gun. Below is Mel's description.

"Without question, the Feinwerkbau Sport Model (known variously as the F-12 or the F-124) is the best air rifle for survival use made anywhere in the world—and by a considerable margin. It is extraordinarily durable, simple to repair, more powerful than any other rifled air arm and it is capable of a very high order of accuracy. Mine has fired several 5 shot groups at 25' which measure between .095" and .12" on centers, and after several months of shooting it now develops a muzzle velocity of 855 fps. In normal use, only three parts can be expected to need replacement: the main spring, the breech seal and the piston seal. Both of these seals are made of durable synthetics which tend to resist both wear and deterioration, and the massive mainspring is unusually sturdy. It is unlikely that any of these components would fail during a single lifetime, given reasonable care and barring abuse, but it would be prudent to stock two spares for each, nevertheless; they are quite inexpensive. If you intend to make serious use of air guns in your survival plans, the

Feinwerkbau is your clear first choice." (Survival Guns, pp. 216-217, Tappan, Janus Press, Box 578, Rogue River, OR 97537.)

I ordered one and at first, I couldn't even cock it. A call to Mel fixed that. One simply grasps the barrel and the stock and bends it down over the knee and it will open up and expose the chamber for loading. When bent all the way, it clicks and you then know it is charged with air and so when loaded and closed, it is almost ready to fire. Cocking the rifle causes a red safety indicator to stick out the rear of the chamber. This must be pushed in before the gun will fire.

A 4X Bushnell scope (not illustrated) is slid over the two ridges above the safety indicator and tightened with an Allen wrench. Before tightening, the scope should be sighted in. This is done by setting up a bag of grain or sand to rest the rifle on so it doesn't twitch around. Then sight it in on a target you can't miss, like at 15 feet away.

Then loosen the scope sight by screwing the eyepiece forward. Then look through the eyepiece and twist one way and the other until the target is clear. Then screw the eyepiece back to lock it in the focussed position.

There are two small knobs in the middle of the scope. Fire the rifle and if it is high or low, take off the plastic cap from the top knob. Then use a coin to turn the screw one way or the other and fire again. You will then know which way to turn it to raise or lower it on the target. The side knob controls the pattern to the right or left. Of course, this is just to show how to sight it in. You will eventually decide on the general range you will be firing from and the adjustments will have to be reset for greater distances.

The rifle comes with a box of 500 flathead pellets. The pellets cost about \$6.00 per 1000.

Mel told me he had killed a fox with his Feinwerkbau and this worked fine. But a little overkill never hurt anybody so I'll show you how to beef up this goody to take on deer and even human marauders.

At first, I bought a packet of 15 No. 2, 3/8 inch brass, flat head wood screws for 40c at the hardware store. Using epoxy resin, I glued the screws onto the flat heads and left them overnight to harden.

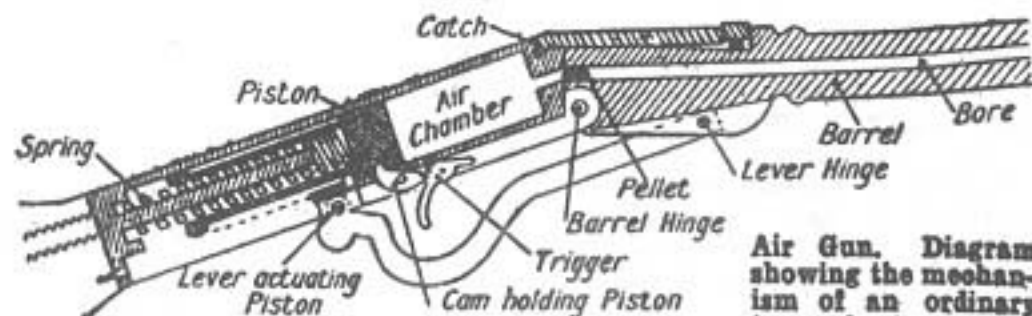
Then I got out the potassium cyanide. This has to be dried over a heater or in an oven since it becomes damp on exposure to the air. When its completely dry, it is ground to a fine powder and mixed with just enough Lepage's mucilage to hold it together. (Don't use white glue as it won't work with this.) Then put a dollop of cyanide on the screw and roll it between the thumb and forefinger until it is

FEATURES for STANDARD MODEL 124

weight 6.7 lbs. length 43 1/2" velocity 800-820 fps. caliber .177 cocking force 18 lbs.

This is the excellent German-made air rifle that has been written about in many books and newsletters. With a specially parallax adjusted scope, it can be used as an excellent weapon for small game hunting. It can be used for teaching safe rifle use to children, in-door practice for improving skills, or pest destruction. **POWERFUL AND ACCURATE** - at 40 feet it will put a pellet through a dry 1" pine board. With a scope, you can make head shots out to 50 yards and beyond. It has the weight and feel of a large caliber rifle and there is basically no recoil or discharge sound to contend with.

EASY TO COCK - no repeated pumping, no CO2 to run out, just one easy cocking stroke to develop the 800 fps. The cocking lever is so designed that it takes only 18 lbs. to cock. **COMPLETE KIT** - We feel that with a quality rifle, you must have the equipment to keep it up. Therefore we will only sell the 124 with an upkeep kit that includes a replacement main spring, piston seal, and O ring, the only parts that should ever need replacing, 500 hunting pellets, oil, oiling needle, and complete instructions on the care and use of precision air rifles.



AIR GUN: How to Look After. The principles on which the various types of air gun work are more or less identical. An air chamber in the form of a cylinder having inside an accurately-fitting piston driven by a powerful spring is attached to the stock. A lever, usually connected to both stock and barrel, which are hinged together, compresses the spring when the barrel is pulled down; the piston is held in position by the trigger, and when the bullet or pellet is inserted, and the barrel replaced and locked by the catch, the gun is ready for use. On the release of the trigger the pellet receives the full force of the compressed air formed by the sudden release of the spring-driven piston.

The only part of an air gun likely to get out of order with ordinary use is the spring. To

effect repairs, and also to clean the internal mechanism, the metal cover must be unscrewed, together with any parts attached thereto. If the spring is weak or broken, a new one must be fitted. The piston should be taken out, the new spring compressed in a vice, tied up with twine, and fitted in position. The trigger catch or attached rocking-cam should be examined for signs of wear, and, if necessary, new ones fitted. The parts should be replaced, and, when they are secure, the string attached to the spring may be burnt with a red-hot wire and the bits pulled out with a wire hook.

properly covered and no wider than the pellet's flat head.

After covering as many screws as I wanted, I dried them over the heater and stored them in a zip-lock plastic baggie to prevent them from becoming moist. They have to be stored this way until shortly before use as moist cyanide would slough off the screw in flight. (The same rule applies to hollowpoint bullets filled with the cyanide-glue mixture. You may consider covering the cyanide-glue with plastic spray but don't. The action of the blood on the cyanide-glue moistens it and circulates it throughout the body within seconds. Plastic spray would keep it from being dispersed.)

At first, I rolled the cyanide-glue on the plain pellet and in the depression in its end. Then I took a chunk of ham and everything else to the Eureka P.D. to demonstrate it.

The cyanide pellets alone went over an inch and half into the ham. The pellets with the screws went in almost three inches, being slightly heavier and sharper. The officer in charge sent an extra cyanide pellet to the Police Lab but the results

aren't in yet. No matter. Estimates of lethal doses run from 2/3rds of a grain to three. Think of a grain of rice or wheat since that's where the measurement comes from. Blood circulates in the body six times per minute so death is quick.

The screw held at least a grain (more than the pellet alone). Even so, one should be sure. I then bought a box of No. 18 3/4 inch flathead wire nails, 2 oz. for 49c. I counted 318 in the box.

I epoxied some nails to pellets and next day covered them with mucilaged cyanide. Three grains or more there. (Note: Don't handle cyanide for more than a few minutes; then wash your hands and anything the cyanide has touched.)

I didn't test the nails on meat but shot four (without cyanide) at a 1 1/2 inch redwood board. Two were not properly centered on the pellet tops and they went in sideways at least 1/4 inch. Figure an inch in flesh and a terrible wound—with cyanide, certainly fatal. The other two were properly centered and buried themselves one inch straight into the redwood. They would have gone about four inches into flesh.

Game downed by cyanide is perfectly safe to eat. A deer carcass will be bled, removing most of the poison. A rabbit or squirrel may be soaked in water for a couple of hours if it makes you feel safer.

I'm not sure of the laws, if any, covering cyanide pellets for air guns. I know they wouldn't be legal to use against humans. Even so, ballistics would be impossible since the pellet becomes completely distorted, unlike most bullets, especially of large caliber.

For air pistols, other models of air rifles, accessories, etc., write Air Rifle Headquarters, Box 327 Grantsville, W. Va. 26147 and ask for their catalog. It's black and white and may be free. Another firm, Beeman's, sells Beeman's Precision Airgun Guide for \$1.50. Send to: Beeman's Precision Airguns, Inc., 47 Paul Dr., San Rafael, CA 94903.

I've included a diagram of the standard air gun from Cassell's Home encyclopedia, 1935. Also look up "Airgun" on page 362.

I consider the Feinwerkbau 124 the best survival airgun. It will last a lifetime with reasonable care. Since its ammo costs only about \$6.00 per thousand you can shoot as much as you like. You can consider it your rabbit gun if you like but with cyanide coated wire nails epoxied to the pellets you can bring down deer or human marauders with ease.

An Application for Small Wounds

From Popular Mechanics 1915

Pure wintergreen oil makes a good local application for all small wounds, bites, scratches, abrasions, etc. There is no germ or microbe, animal or vegetable, dead or living, that can withstand this oil, and at the same time it is not injurious to living tissues. A few drops gently rubbed in where there is apt to be any infection is sufficient.

An infection always follows the wound of a bullet or the scratch of a brass pin, with irritation extending up the limb or part threatening tetanus or lockjaw. These symptoms are manifested by spasmodic pains which shoot upward, but are quickly subdued, if the oil is applied along the track of the pain or infection. This oil is equally effective when locally applied to tendons or ligaments which have been unduly strained.

An ounce of the pure oil does not cost much, and it should be kept in every shop and household. If 5 or 10 per cent of olive oil is added to it, the oil will have more body and will last longer.

Courage, A Treatise For Our Times

By Kurt Saxon

Everyone has his own definition of courage. My definition is doing what one is afraid to do. Over the long haul, I believe that courage is hanging in there, doing the drudgery, taking flack from the apathetic and getting things done which most people don't appreciate and believe should never have been started in the first place.

In my opinion, the best description of courage in all its forms was written by Horace Porter, a Union lieutenant at the battle of Fort Pulaski in 1862. He was a constant combat officer throughout the Civil war and rose to general and was aid-de-camp to General Ulysses S. Grant.

His accounts of individual courage will be familiar to any person who has faced danger whether in civilian life or in combat, in any nation or in any age.

An interesting sidelight is his description of soldiers dodging bullets. The phrase has come down to us only figuratively. However, during the American Civil War, the bullets were Minie balls of 50 caliber, hollowed at the back. They were propelled by black powder and expanded on leaving the barrel to about the size of a half-dollar. Thus, under the right light and the proper angles, one could actually see them coming.

THE PHILOSOPHY OF COURAGE.

From THE CENTURY MAGAZINE, June 1888

By General Horace Porter



BREVET BRIGADIER-GENERAL HORACE PORTER.



FRENCH writer has said that every mistake made in life can be traced to fear. Though this was doubtless written more to shape an epigram than to state a fact,—and epigrams are generally regarded as jewels purchased at the expense of veracity,—yet the more we reflect upon the remark the more we are impressed with its truth.

Fear, above all things else, enfeebles the vigor of man's actions, supplants decision by vacillation, and opens the road to error. When one seeks counsel of one's fears, judgment ceases to obtrude advice.

Courage, on the other hand, is universally recognized as the manliest of all human attributes; it nerves its possessor for resolute attempts, and equips him for putting forth his

supreme efforts. Powerful aristocracies have been founded with courage as the sole patent of nobility; kings have maintained their dynasties with no other virtue to commend them to their subjects. A once popular farce set forth these two opposite traits in human nature under the title of "The nervous man and the man of nerve."

Courage has so many different natures, assumes so many different forms, and is subject to so many eccentricities, that it is hard to define it. To separate it into the two grand divisions of moral courage and physical courage is a simple matter, but when the subdivisions of these are to be determined, the task is confronted with formidable difficulties.

Few men possess all the various forms of courage. One man may be utterly fearless in the most perilous storm at sea, while on land he may be afraid to travel at the rate of twenty-five miles an hour on a first-class railroad, and, sailor-like, expends his sympathies in pitying "poor unhappy folks ashore." A locomotive engineer on an Eastern railway, who was always selected for his "nerve" when a fast "special" was to be sent out, and whose courage, repeatedly displayed in appalling accidents, had become proverbial, was afraid in the quiet of his own home to go upstairs alone in the dark.

In ascending a Southern river on a steamboat, towards the close of our civil war, we had an officer on board who, during three years of fighting, had treated shot and shell in action with an indifference that made him a marvel of courage; but on this expedition he manifested a singular fear of torpedoes, put on enough life-preservers to float an anchor, and stood at the stern of the boat ready, at the first sign of danger, to plunge into the water with the promptness of a Baptist convert. He once came very near jumping overboard at the sound of a sudden escape of steam

from the boiler. He made no disguise of his nervousness at this new form of danger. I recollect a company officer of infantry who never seemed to know what the word fear meant under any circumstances until his promotion to a higher rank compelled him to mount a horse, and then his mind knew no peace. A sudden snort from the beast alarmed him more than the opening of a battery, and the pricking up of the animal's ears had more terrors for him than a bayonet charge.

These instances, though numerous, are the exceptions, not the rule. They can often be accounted for by the fact that the victim had suffered a severe fright, perhaps in childhood, which produced a permanent shock to his nerves, and made him timid ever after respecting the particular form of danger to which he had been exposed. An acquaintance of mine whose repeated acts of gallantry in the field had convinced all his comrades that he had been born without the sense of fear was seen to give a wide berth to any horned animals that came in sight. Whenever a drove of commissary's cattle were encountered on the road, he began a series of well-timed maneuvers with a view to getting a fence between himself and them in the shortest possible time. Their approach seemed to demoralize him as much as a cavalry charge of the enemy elated him. The providing of an army with "beef on the hoof" was one of the methods of military logistics which had more terrors for him than a prospect of starvation. When twitted on the subject, he one day said in explanation, that, when a child, a cow had once chased him, thrown him down, and then tossed him on her horns, and he had never recovered from the shock, or been able to banish from his mind the sense of terror the circumstance produced. It was the burned child dreading the fire.

This instinct is common to all animals. At a country station on one of our railways a pig used to be a constant visitor, and drove a thriving business in picking up stray grains of corn which dropped from the bags as they were loaded on the cars. One day the pig's greed so far overmastered his discretion that his tail got nipped between the brake-shoe and the car-wheel, and when the train started the tail was jerked out by the root. The victim of this sudden catastrophe was now confronted with the dismal prospect of having to navigate through the rest of life with his steering apparatus a total wreck. He continued coming to the station after that, but whenever he heard the clatter of an approaching train, he hurried off to a safe distance and backed up close against a brick wall till the cars had passed; he was never going to permit himself to be subject to the risk of such an indignity again, even though there was no longer any tail left to be pulled out. He had acquired sufficient railroad experience to appreciate the magnitude of the loss of terminal facilities.

As one's physical condition is affected by circumstances of health and sickness, so does one's courage vary under different surroundings. Troops, after being refreshed by a rest and a good meal, have stood their ground under a fire from which they would have fled in confusion if tired and hungry. An empty stomach, like conscience, makes cowards of us all. The Duke of Wellington proved himself

a philosopher when he said, "An army moves principally upon its belly." In the days when personal difficulties were settled under the "code," the parties never tried to screw their courage to the sticking-point on empty stomachs, but "pistols and coffee" always went hand in hand.

In the successful attack made by Admiral Du Pont with his fleet upon the Confederate forts which commanded Port Royal harbor, when the dinner hour arrived the admiral directed rations to be served as usual, and the crews were ordered to cease loading their guns and go to loading their stomachs to fortify themselves for the continuation of the battle. The commanding officer was severely criticised for this at the time, but it was afterwards generally conceded that he understood the true relations between the nerves and the stomach, and gained the victory all the sooner by taking time to lodge that dinner where it would do the most good. An attack of dyspepsia or a torpid liver will sometimes rob a man of half his natural courage; rabbits in his path then become magnified into lions, and mole-hills into mountains. Napoleon lost the battle of Leipsic from eating too heavy a dinner and being seized with a fit of the blues brought on by indigestion. As the Latin roots of the word locate the source of courage in the heart, and as the seat of all courage is believed by many to be in the mind, no one would attempt the ungracious and unsentimental task of trying to transfer its location to the stomach, but facts point to the belief that the condition of the stomach has something to do even with this high attribute of man.

Courage, like everything else, wears out. Troops used to go into action during our late war displaying a coolness and steadiness the first day that made them seem as if the screeching of shot and shell was the music on which they had been brought up. After fighting a couple of days, their nerves gradually lost their tension, their buoyancy of spirits gave way, and dangers they would have laughed at the first day often sent them panic-stricken to the rear on the third.

It was always a curious sight in camp after a three-days' fight to watch the effect of the sensitiveness of the nerves; men would start at the slightest sound, and dodge at the flight of a bird or a pebble tossed at them. One of the chief amusements on such occasions used to be to throw stones and chips past one another's heads to see the active dodging that would follow.

Recruits sometimes rush into dangers from which veterans would shrink. When Thomas was holding on to his position at Chickamauga on the afternoon of the second day, and resisting charge after charge of an enemy flushed with success, General Granger came up with a division of troops, many of whom had never before been under fire. As soon as they were deployed in front of the enemy, they set up a yell, sprang over the earth-works, charged into his ranks, and created such consternation that the Confederate veterans were paralyzed by the very audacity of such conduct. Granger said, as he watched their movements, "Just look at them; they don't know any better; they think that's the way it ought to be done. I'll bet they'll never do it again." Men, like children,

are often ignorant of danger till they learn its terrors in the school of experience.

Every soldier understands why "two o'clock in the morning" courage is recognized as courage in its highest form. At that time many hours

of fasting have occurred since the evening meal; enough sleep has not yet been had to restore the nervous system to its normal condition after the fatigue and excitement of the previous day; it is the hour of darkness and silence, when the mind magnifies the slightest sounds. The stoutest nerves require a great deal of bracing when a camp is startled out of its sleep by an attack at such an hour.

Nearly all persons are more timid when alone. The feeling of lonesomeness is akin to fear. At Spotsylvania a staff officer flinched and turned back when bearing a message to a part of the field which required him to pass along a road exposed to a short-range fire from the enemy. His courage had stood every test when in the company of others, but on this occasion he had set out alone, and had been seized with a fear which at the time completely unmanned him.

A woman when quite alone in a house at night may be tortured by a sense of fear which completely destroys her peace of mind; but let there be a child in the same room with her, and she will feel but little apprehension of danger. The relief comes not from any protection she believes the child could afford, but from her release from the fearful sense of lonesomeness which had unnerved her.

There is a peculiar significance in "shoulder to shoulder" courage. It springs from a sense of the strength which comes from union, the confidence which lies in comradeship, the support derived from a familiar "touch of the elbow."

A battery of artillery has often been ordered to open fire when there was no chance of doing the enemy any damage, merely for the moral effect upon the infantry, whose courage is always increased by feeling that they have the support of the noise of the sister arm of the service, if nothing else.

Indifference to danger is not always the form of courage which should entitle its possessor to the highest credit. It is a negative virtue as compared with the quality which enables one to perform a dangerous duty while realizing the full measure of the peril encountered.

These two traits are best illustrated by the old story of the two soldiers whose regiment was charging up a hill in a desperate attempt to capture a battery. When half-way up, one of them turned to the other and said, "Why, you're as pale as a sheet; you look like a ghost; I believe you're afraid." "Yes, I am," was the answer; "and if you were half as much afraid as I am you'd have run long ago." It is something higher than physical courage, it is a species of moral courage, which recognizes the danger and yet overmasters the sense of fear. When the famous mine in front of Petersburg had been completed, and the National troops drawn up ready to charge the enemy's works as soon as the mine had done its work in creating a breach, the signal was given just before daylight, the fuse was lighted, and the command stood waiting with intense anxiety for the explosion which was to

follow. But seconds, then minutes, then tens of minutes passed, and still no sound from the mine. The suspense became painful, and the gloom of disappointment overspread the anxious faces of officers and men. The fuse had been spliced about midway. It was now thought that there was a defect in the splice, and that it was at this point that the fuse was hanging fire. The day was breaking, the enemy was becoming alert at sight of our unmasked columns, there was not a moment to be lost. Lieutenant Doughty and Sergeant Rees, of the 48th Pennsylvania infantry, now volunteered to examine the fuse. They entered the long dark gallery which led to the mine, and without stopping to calculate the chances of life, calmly exposed themselves to one of the most horrible forms of death. With no excitement to lend them its intoxication, with nothing to divert their minds from the fate which seemed to await them, they followed the course of the fuse through the long subterranean passage, found the defect at which the spark had been arrested, and made a new splice. On their return the match was again applied, and the train was now prompt to do its deadly work. These men displayed even a higher order of courage than those who afterwards charged into the breach.

Perhaps the most striking case of desperate and deliberate courage which the history of modern warfare has furnished was witnessed at Cold Harbor. The men had been repeatedly repulsed in assaulting earth-works, had each time lost heavily, and had become impressed with the conviction that such attacks meant certain death. One evening, after a dangerous assault had been ordered for day-

light the next morning, I noticed in passing along the line that many of the men had taken off their coats and seemed engaged in mending rents in the back. Upon closer examination I found that they were calmly writing their names and home addresses on slips of paper, and pinning these slips upon the backs of their coats, so that their dead bodies might be recognized upon the field and their fate made known to their friends at home. Never was there a more gallant assault than that made by those men the next day, though their act of the night before bore painful proof that they had entered upon their work without a hope of surviving. Such courage is more than heroic; it is sublime.

Recklessness often masquerades as courage, but it is made of different mettle. Plato, in reasoning upon this subject, says: "As knowledge without justice ought to be called cunning rather than wisdom, so a mind prepared to meet danger, if exerted by its own eagerness and not the public good, deserves the name of audacity rather than of courage."

Courage born of passion or excitement should always be looked upon with suspicion. It may fail at the very moment it is most needed. I remember a soldier in one of the regular batteries in the Army of the Cumberland, who had displayed conspicuous bravery in a dozen engagements while serving his gun as a cannoneer. At the battle of Chickamauga he was assigned to duty as a driver, and instead of participating in the excitement of loading and firing, he had nothing to do but sit quietly on his horse and watch the

havoc created around him by the enemy's shot. He soon became seized with a terror which completely unmanned him, and after the battle he implored his commanding officer to send him back to his gun, saying that if he ever went into another engagement as a driver, he felt certain he should run away and lose all the reputation he had ever gained. His courage had disappeared with the excitement which inspired it.

Men have performed deeds of bravery by being goaded on by anger or stung with taunts, but those who require to be lashed into a rage before they can key up their nerves sufficiently to meet danger are not the possessors of a courage which is trustworthy. Fierce fires soon burn out. According to Shaftesbury, "Rage can make a coward fight, but fury or anger can never be placed to the account of courage."

It is a fact known to every soldier that the most courageous men indulge the least in brutal bullying, and those who exhibit all the pluck necessary to make them leaders in street rows and prize rings are the first to shirk an encounter in which death stares them in the face. During our civil war the regiments which were composed of plug-uglies, thugs, and midnight rounders, with noses laid over to one side as evidence of their prowess in bar-room mills and paving-stone riots, were generally cringing cowards in battle, and the little courage they exhibited was of an exceedingly evanescent order. A graduate of a volunteer fire company arrived in Washington one day, in the ranks of a regiment in which he had enlisted. As he stepped from the cars he took off his coat, hung it over his arm, tilted his hat a little farther up behind, brushed his soap-locks forward with his hand, and said to a midget of a newsboy standing at the station, "I say, sonny, hev you seen anything of Je-Jeff Davis around h'yar? Ve 're lookin' fur him."

"You 'd better go down to Richmond and do yer lookin'," replied the boy.

"Well now, sonny, don't you worry none about that," said this forerunner of destruction. "That 's de very town ve 're goin' fur, and ven ve gets inside of it, thar von't be anything but vacant lots around thar, you bet."

In his first fight this same plunging swash-buckler suddenly became seized with a feeling of marked tenderness towards his fellow-beings generally, concluded he did not want to hurt anybody, and soon struck his best gait in an effort to join the baggage-wagon committee in the rear.

Courage, like most other qualities, is never assured until it has been tested. No man knows precisely how he will behave in battle until he has been under fire, and the mind of many a gallant fellow has been sorely perplexed by the doubts that have entered it previous to his first fight. He sometimes fears his courage, like Bob Acres's, may ooze out, and that he may behave like the enthusiastic young hunter in pursuit of his first bear, who followed the trail vigorously all day, spoiling for a chance to get to close quarters with the animal, but in the evening suddenly turned back, giving as an explanation of his abrupt abandonment of the hunt that the bear's tracks were getting too fresh.

At the beginning of our war officers felt that,

as untested men, they ought to do many things for the sake of appearance that were wholly unnecessary. This, at times, led to a great deal of posing for effect and useless exposure of life. Officers used to accompany assaulting columns over causeways on horseback, and occupy the most exposed positions that could be found. They were not playing the bravo: they were confirming their own belief in their courage, and acting under the impression that bravery ought not only to be undoubted, but conspicuous. They were simply putting their courage beyond suspicion.

At a later period of the war, when men began to plume themselves as veterans, they could afford to be more conservative; they had won their spurs; their reputations were established; they were beyond reproach. Officers then dismounted to lead close assaults, dodged shots to their hearts' content, did not hesitate to avail themselves of the cover of earth-works when it was wise to seek such shelter, and resorted to many acts which conserved human life, and in no wise detracted from their efficiency as soldiers. There was no longer anything done for buncombe; they had settled down to practical business. One day, in the last year of the war, General Butler rode out with his staff to see how the work was progressing in the digging of his famous Dutch Gap Canal, that was to cut off a bend in the James River. He stopped at a point which soon became a conspicuous target for the enemy's batteries. After a while a staff officer, who had won a famous reputation by his repeated acts of personal courage, saw the uselessness of the exposure of so many valuable officers, and proposed to the general to move to another position. The general turned upon him sharply and said, "Any officer of the staff who 's afraid can go back to camp." The officer at once turned his horse about, touched his hat, and with a quizzical look at his commanding officer said, "Good morning, General, I 'm afraid," and rode off to a position where he could be of just as much service and not be a party to an exhibition of recklessness. Such an act before his courage had been tested would have cost him his commission. Now he could afford to exercise the wisdom of a veteran; and no one dared question his motives.

There have been many instances which go to prove that a young soldier ought not always to be hastily sacrificed for flinching in his first engagement. Upon one occasion, during a desperate assault in which the attacking column was under a withering fire, I saw a company officer desert his men, and run to the rear, as pale as a corpse, trembling like an aspen, the picture of an abject craven. He even tore off his shoulder-straps that he might not be recognized as an officer. He heeded neither urgings nor threats; he was past all shame; he was absolutely demented. It was the more distressing because he was a man of great intelligence and possessed many good qualities. When the engagement was over, the only question seemed to be whether he should be cashiered or shot; but he begged so hard of his commanding officer to give him another trial, to grant him one more chance to redeem himself from disgrace, and gave such earnest pledges for his future conduct, that he was finally released from arrest

and allowed to go into battle again with his company. He fulfilled his pledges most religiously. Wherever there was danger he was seen in the midst of it; his conduct in every subsequent fight was that of a hero; and he was finally promoted to the rank of a field officer. He had effaced the blot from his escutcheon. The man was no coward at heart; he had for the moment, in army parlance, "lost his grip" under that first murderous fire.

Boucicault, in his play called the "Relief of Lucknow," introduces the character of a young English officer fired with professional ambition, who has just joined the service, and finds himself in the beleaguered city, surrounded by rebels. He is ordered to make his way through the enemy and carry a message to the column advancing to the garrison's relief; but his heart fails him, his courage deserts him, and he turns back and stands before a brother officer a miserable poltroon. This officer brings him to a realizing sense of the wretched position in which he has placed himself, and procures him an opportunity to wipe out his disgrace. He embraces it, and afterwards becomes one of the most heroic figures in the siege. In conversation with Mr. Boucicault, I once asked him whether this scene was founded on fact. He said it was not, that he had introduced the incident merely because he considered it dramatic, and somewhat novel in a military play. I then told him the story related above, about the company officer whose nerves were unstrung in his first encounter with danger, as confirmative of the truthfulness with which the distinguished author had held the mirror up to nature in his admirable military drama.

The cases of recovery, however, from the disease of fear are rare. Cowardice is generally a constitutional malady, and has to be recognized and dealt with as such. General Sheridan used to estimate that about twenty-five per centum of the men were lacking in the requisite courage for battle, and he at times tried to have the weak-kneed troopers singled out and assigned to hold the horses of the other men when the cavalry dismounted to fight on foot. He said we had this complement of the faint-hearted in the ranks; we could not very well deplete the forces by getting rid of them, and the only philosophical plan was to utilize them by giving them some duty which their unsoldierly nerves could stand.

A curious characteristic of fear is that it generally affects persons when death is threatened in an inverse ratio to the value of their lives. In battle an officer upon whom the fate of a command depends will risk his life generously unmoved by a sense of fear, while a shirk whose life is of no earthly use to anybody will skulk in the rear and dodge all danger. When encountering heavy weather in a sail-boat an able-bodied young fellow, with every prospect of a career of usefulness before him, often sits calmly through the danger, while some aged invalid, with one foot already in the grave, will prove himself a martyr to his fears, squirm at every lurch of the boat, and summon all hands to stand by to save him.

A sense of cowardice seems to rob a being of all his manhood. When you see a person acting the coward you may sting him with reproach, hurl at him every epithet of con-

tempt, even cudgel him as you would a cur, and there is usually not enough manhood left in him to resent it; no sense of shame to which appeal can be made; no sensibilities to wound.

The question is often asked whether men in battle, when they break, run to the rear very fast. Usually they do not; they often do not run at all; the most provoking part of it is that they deliberately walk away; and as to reasoning with them, you might as well try to reason with lobsters when they scramble out of a basket and start for the water.

There was one soldier, however, in a Western army, who in a retreat proved an exception to the rule and showed himself still master of the faculty of resentment. An irreverent general officer, who was famous for designating his men on all critical occasions by a title which was anything but a pet name, called out to this soldier who was breaking for the rear:

"Halt there, turn round, and get back to the front, you —."

"Look-ee here, Gin'ral," said the man, cocking his gun and taking aim at the officer's head, "when a man calls me a name sich es that, it's his last departin' word."

"Oh, put up your gun," said the general. "I did n't mean anything. I forgot your other name."

Reasoning dictated by fear is seldom logical. When a man becomes panic-stricken he recognizes but one principle for his guidance, that self-preservation is the first law of nature, and is ready to repeat the cry, "I would give all my fame for a pot of ale and safety." The instincts of fear do not always guide him to a safe place. In his confusion he often rushes into more danger, and becomes a ludicrous object to watch. In one of our prominent battles, a soldier belonging to a command which was supporting a battery was lying down with the rest of his regiment to obtain some cover afforded by a bit of rolling ground. The fire soon became so hot that his nerves could no longer stand the strain upon them, and he sprang to his feet and started for the rear. He soon found himself in a level field that was being plowed by the shot and shell which ricocheted over the rolling ground in front, and saw that he had got out of the frying-pan into the fire.

"What are you doing there?" cried an officer.

"Well," said the man, "I 'm looking for the rear of this army, but it don't seem to have any."

The question most frequently asked of soldiers is, "How does a man feel in battle?" There is a belief, among some who have never indulged in the pastime of setting themselves up as targets to be shot at, that there is a delicious sort of exhilaration experienced in battle, which arouses a romantic enthusiasm, surfeits the mind with delightful sensations, makes one yearn for a life-time of fighting, and feel that peace is a pusillanimous sort of thing at best. Others suppose, on the contrary, that one's knees rattle like a Spanish *bailarina's* castanets, and that one's mind dwells on little else than the most approved means of running away.

A happy mean between these two extremes would doubtless define the condition of the average man when he finds that as a

soldier he is compelled to devote himself to stopping bullets as well as directing them. He stands his ground and faces the dangers into which his profession leads him, under a sense of duty and a regard for his self-respect, but often feels that the sooner the firing ceases the better it would accord with his notion of the general fitness of things, and that if the enemy is going to fall back the present moment would be as good a time as any at which to begin such a highly judicious and commendable movement. Braving danger, of course, has its compensations. "The blood more stirs to rouse a lion than to start a hare." In the excitement of a charge, or in the enthusiasm of approaching victory, there is a sense of pleasure which no one should attempt to under-rate. It is the gratification which is always born of success, and, coming to one at the supreme moment of a favorable crisis in battle, rewards the soldier for many severe trials and perilous risks.

The physical effect produced upon different men in the presence of danger forms an interesting study, but in many cases the outward signs as indicated by the actions of the individual in no wise measure the degree of his courage or his fear. The practice, for instance, of dodging shots, "jackknifing" under fire, proceeds from a nervousness which is often purely physical, and has but little more significance as a test of courage than winking when something is thrown in one's face. The act is entirely involuntary. A general officer who was killed at the second battle of Bull Run was one of the most gallant soldiers that ever drew a blade. Everybody had predicted his early death from the constant and unnecessary exposure to which he subjected himself. When under fire, the agile dodging he performed was a whole gymnastic exercise in itself. His head would dart from side to side and occasionally bob down to his horse's neck with all the vigor of a signal-flag in waving a message. These actions were entirely beyond his control, and were no indications whatever of fear. Dodging to some extent under a heavy infantry fire is very common. I can recall only two persons who throughout a rattling musketry fire always sat in their saddles without moving a muscle or even winking an eye; one was a bugler in the regular cavalry, and the other was General Grant.

Two general officers in the field, conspicuous for their fearlessness, possessed such nervous temperaments physically that, under the strain to which they were subjected in the face of a destructive fire, they invariably became affected with nausea, and, as our English friends say of seasick people, they frequently became "actively ill." It was a source of great mortification to them, but it was constitutional; they could not control it, and no one could attribute it to fear.

The realization of danger is always egotistical. Men waiting to go into action turn their conversation upon their previous hair-breadth escapes and the havoc made among their comrades, just as passengers on a steamer invariably assemble in a storm and relate their former harrowing experiences in the "roaring forties," and travelers on a railway train as soon as it gets to running at a break-neck speed on a dark night begin to tell each other their blood-curdling stories of fatal telescopings and tangled

wrecks. These recitals are not calculated to be cheering in their effects, but human nature is so constituted that the mind will dwell upon the horrors which the presence of danger always conjures up, and it seems to find a melancholy relief in expending its thoughts in words.

Superstition, which is the child of fear, is common among all people who lead a life surrounded by dangers. Sailors are proverbially superstitious, and it is natural that such a feeling should enter an army and sometimes warp men's courage. Presentiments are usually common with recruits, but after repeatedly finding their most clearly defined apprehensions unrealized they lose faith in such imaginings, and begin to look upon these things as so lost to all sense of punctuality that they no longer believe in their coming. I have known but one presentiment which was fulfilled, and that was accomplished in such a bungling way as to be robbed of all respect for its methods.

The practical questions involved in this discussion are, Can courage be taught, and, if so, what are the best means of education? Numerous experiments have been attempted in this direction. I knew the father of a large family of boys who became greatly distressed on account of the timidity shown by several of them, and set about educating them up to a higher standard of courage after a method which he had practiced successfully with dumb animals. He had found, for instance, that when a horse showed great terror at sight of a railway train in motion, the surest way to break him of it was to throw him down close to the track and confine him in that position till the train had thundered by. After subjecting the animal to this mode of discipline two or three times its sense of fear was entirely overcome. He applied similar lessons to his boys. If one was afraid to be alone in the dark, the father made him wander repeatedly through the attic rooms at midnight without a light. If another had a dread of the water, he compelled him to swim swift streams and dive off high landings. The practice was disagreeably heroic for the boys, but the father insisted that it finally drove all fear from the most timid of them. He proceeded upon the theory that fear is fed by the imagination, and as soon as any one is convinced that the objects dreaded are harmless, all fear of them will vanish. He evidently believed, with Schiller, that the chief element in the sense of fear is the unknown.

Some years ago a gentleman traveling on a European steamer became such a victim to his terror of the sea that he attracted universal attention. He allowed his mind to dwell constantly upon the objects of his fears. A morbid curiosity led him to take a look into the boiler-room and watch the blazing fires just before going to bed; every few hours in the night he would open his state-room door and sniff the air to find whether he could notice the smell of smoke, and prowled around through the passage-ways to see just when the expected conflagration was going to break out. In a storm he would watch the waves in an agony of fear, in the confident belief that each one was going to swallow up the ship. Finding his business would require him to make frequent ocean trips, he set himself to work on the "mind cure." He gradually schooled his mind until, by a strong effort of

the will, it could be in a great measure diverted from dwelling on the causes of his fears. When a sense of terror seized him he struggled manfully to concentrate his thoughts on other subjects, and finally he so far succeeded that, except in very dangerous gales, his fears were completely controlled, and he began to acquiesce in the popular belief that, after all, crossing the ocean was about as safe as crossing Broadway, New York, in the era of omnibuses.

The peculiarity of the cases just related, however, lies in the fact that the dangers were mainly unreal, and all the mind required was to be assured of the harmlessness of the objects which had inspired its fears. If the dangers had been real, and their effects had been destructive, the training by which the fear was expected to be overcome would not have been so effectual. If the father mentioned above had attempted to silence a son's fear of being shot by sending him into battle, the son, instead of finding his apprehensions unrealized would have seen that shots were fatal and that there was actual destruction of life all around him; his worst fears would have been realized, and in this mode of educating him to a higher standard of courage the lessons taught would doubtless have been found unprofitable.

It is true that a person may often nerve himself to meet danger courageously if he has time to contemplate the coming peril, philosophize upon the situation, and thus avoid the effects of the shock which sudden danger always brings. A spy in war, or a criminal who has committed a capital offense, may at the moment of his capture evince an agony of fear and become totally unmanned; but after undergoing trial and a term of imprisonment, and dwelling upon the fate which awaits him and from which there is no escape, he may go to his execution without a tremor, and face death with the calmness of a Spartan.

Are there, then, any means by which man can be educated up to a degree of courage which will brave the actual danger of facing death? While heroes, in the great majority of cases, are, like poets, born, not made, yet courage can undoubtedly be acquired in many ways. Take two youngsters born with equal degrees of courage; let one remain in a quiet city, playing the milk-sop in a modern Capua, leading an unambitious, namby-pamby life, surrounded by all the safeguards of civilization, while the other goes out on the frontier, runs his chances in encounters with wild animals, finds that to make his way he must take his life in his hand, and assert his rights, if necessary, with deadly weapons, and knows he will be drummed out of the community if he is once caught showing the white feather. In the one particular trait of personal courage the frontiersman will undoubtedly become the superior of the lad who has remained at home. It is perhaps a confirmation of Guizot's remark, however, that in every country the value set upon human life is in proportion to the degree of civilization. Take the case of military schools, in which courage is inculcated from entrance to graduation, where cowardice is recognized as the unpardonable sin, and an exhibition of fear on the part of a lad in riding a bucking horse, or even in a boyish personal encounter with his fellows, makes it infamous for others to as-

sociate with him, and sends him like a leper outside the camp. The standard of courage under such circumstances is unquestionably raised to a higher grade than in a school in which this quality is not dwelt upon as the saving virtue.

Ancient Greece made her sons a nation of heroes by holding up valor as the only true badge of earthly glory. She sought out every means of claiming for her heroes the admiration of the people, and taught courage by the force of example. It is said that for ages after the battle of Thermopylae every scholar in the public schools of Greece was required each day to recite from memory the names of the three hundred heroes who fell in defending that pass.

Napoleon taught Frenchmen that the sum of worldly glory was the reward gained by courage on the field. Kingdoms were bestowed upon victorious marshals, and promotion and decorations evidenced the prompt recognition of every gallant deed. When La Tour d'Auvergne, accounted the bravest grenadier in the ranks of the grand army, finally fell, pierced by the bullets of the enemies of France, a general order was issued directing that his name should be kept on the active list of his regiment, that it should be called at every roll-call, and each time a comrade should answer from the ranks, "Dead on the field of honor." By every device that could appeal to men's ambition this wizard of modern warfare educated his people to be paragons of valor, and, until his training-school closed its doors, the French armies set all Europe an example in courage.

Discipline, that well-spring of victory, is recognized as one of the most potent means of raising the standard of courage in an army. It teaches men that their best reliance is in their own bravery; gives them confidence in each other; removes the fear that they may not be properly supported in emergencies; convinces them that they are part of an intelligent machine moving methodically, under perfect control and not guided by incompetency, and establishes that *esprit de corps* which goes so far towards making armies formidable in war. It was discipline which enabled the commander of the troops on board the English ship, when foundering, to form his men in line on deck, present arms, and go down with the vessel, while the band played "God save the King."

The moral influence of the prestige which comes from past success does much towards developing courage. Instances of this are innumerable. I happened to be in Chicago in May, 1886, when the anarchists attacked the police and threw the destructive bomb into their ranks, and when that force rallied so gallantly, drove the anarchists from their strongholds, scattered them like chaff before

the wind, and became the object of the highest honors that the best citizens of Chicago could bestow. Before that event the police had been strictly on the defense; their small squads huddled together for protection had been boldly attacked, and they had been ordered from pillar to post to rescue their comrades from the fierce onslaughts that were being made upon them by a foe whose reckless acts and exaggerated numbers had almost paralyzed

the community. But the next day after the suppression of the Haymarket riot the police went forth wearing the laurels of success; they swaggered like the returned heroes of Austerlitz; each man seemed to feel two feet higher in stature and competent to cope single-handed with an army of anarchists. One of these policemen undertook to guard a railway station where a dozen were required the day before; they searched single-handed for anarchists like ferrets for rats; the city was safe from that hour. The prestige born of that memorable achievement had been a complete education in courage.

Moral courage will always rank higher than physical. The one is a daily necessity, while the

other may be required only in emergencies.

It cannot be doubted that the crime of embezzlement, unhappily becoming so common among employes who handle money, is mainly due to lack of moral courage. The history of the unfaithful cashier is always the same old story. He has incurred a debt through an extra bit of extravagance or taking a turn in the stock market, in the certain belief in success. If he had the moral courage to tell his employer frankly of his pressing necessities, make a clean breast of it, and ask advice and assistance at the outset, he would, in nine cases out of ten, if a valuable employe, receive good counsel, be assisted to a loan, helped to bridge over the results of

his indiscretion, and be saved from ultimate ruin. His moral cowardice leads him to steal money with which to silence pressing creditors or to gamble in the hope of freeing himself from debt, and, when matters go from bad to worse, carries him panic-stricken to Canada to end his days as a branded criminal and a fugitive from justice.

Morality cannot flourish without courage; criminality certainly thrives upon the lack of it. If we cannot go so far as to believe with the Frenchman that every mistake in life may be traced to fear, we can at least agree with the philosopher who said, "Great talents have been lost for want of a little courage."

Horace Porter.



Fig. 1. Screen made from a grass-matting rug glued between frames of window-stop molding

DECORATIVE Folding Screens AND HOW TO MAKE THEM



Fig. 2. Tacking matting on the back of one of the frames. The molding is rabbeted on the back to form a recess for the matting

Wood and Metal Frames—

Matting, Silk, and Wall-Paper

Coverings—Plywood and

Wall Board—Photomurals

By
MERLE
TERRILL

IN THE construction of folding screens, the amateur craftsman has an exceptional opportunity to create something that is beautiful in itself and also of considerable utility. One or more screens can be used in almost every home as a decoration, to add a bit of light or color to an otherwise bare wall or corner, to conceal some unsightly object, or to block off part of a room.

One attractive screen illustrated (Fig. 1) is nothing more than sec-

tions of a Japanese grass rug glued between frames made of window-stop molding. The molding should be rabbeted on the back to provide a recess for the matting, and the corners should be strengthened with metal braces (Fig. 2). Any design on the rug should be carefully matched on the different panels. Other coarsely woven fabrics, such as monk's cloth or burlap, could be substituted for the grass matting with equally good results.

For a lighter screen, a thin cloth can

be used for the panels, and the frame made of metal tubing. In Fig. 3 the frame is an aluminum tube, and the panel is of silk. The tube is slotted with a hack-saw blade and shaped on a form (Fig. 4). If the tube is cut open before bending, the curved section should be filled with lead to keep it from kinking. After the tube is bent, the lead can be melted out.

The cloth is doubled, and the edges are sewed together to form a sack like an oversize pillowcase. The edge of the cloth is slipped into the tube and held by sliding a coil spring, such as a spring curtain rod, into the tube and inside the cloth (Fig. 7). The spring is pushed all the way around, pulling the cloth into the tube and holding it securely.

Before fastening the cloth to the frame, however, a wooden rod, to which the cloth is attached (Fig. 6), is slipped inside the bottom tube. A short length of tube is split in half and screwed onto each end (as in Fig. 5) and then slipped into the side frame as illustrated. After the cloth is fastened to the frame all around, the crosspiece is pulled down to stretch the cloth, and secured with small screws.

In making solid screens, either plywood or hard-pressed composition board may be used. For a novel ef-

fect, try this: Boil a piece of $\frac{1}{8}$ -in. hard-pressed board in water for fifteen minutes and clamp it over a curved form until dry. Cover it with flexible wood or the less expensive imitation woods made on paper. If you construct the screen in sections, hinge the sections together with copper hinges made as detailed in an accompanying drawing because the thinness of the panels will not permit regular screen hinges to be used.

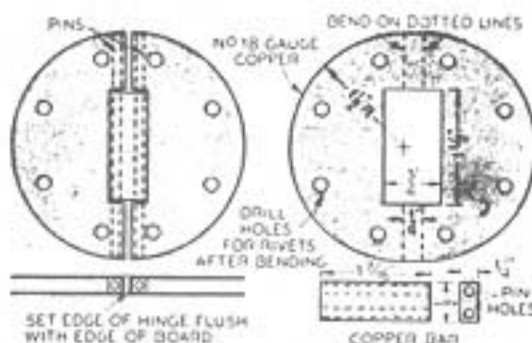
Although screen panels may be made of solid plywood, a better way is to glue sheets of $\frac{1}{8}$ -in. plywood on each side of light frames. This will give a lighter screen and will also eliminate twisting, which is apt to occur if a single sheet of thicker plywood is used.

For a truly beautiful screen, there is nothing like a photomural. If you can make your own enlargements, a photomural like that shown below need not cost more than three dollars. If possible, buy the paper in rolls and make the panels in one piece to avoid seams. If you cannot avoid seams, make the picture so that the sections overlap a

little; then when you mount them, slip a thin strip of metal under the overlapping portion and cut through both sheets with a razor blade. This will result in a perfect joint.

To make a sketch for a special screen, fasten a sheet of paper on the wall and project a photograph onto this as a guide.

Also, don't overlook that old standby of folding screens—wall paper! You can find hundreds of designs and colors, ranging from small figures and all-over designs to large tapestries and colorful landscapes and murals.



If thin, hard-pressed composition board is used, special hinges are made from copper

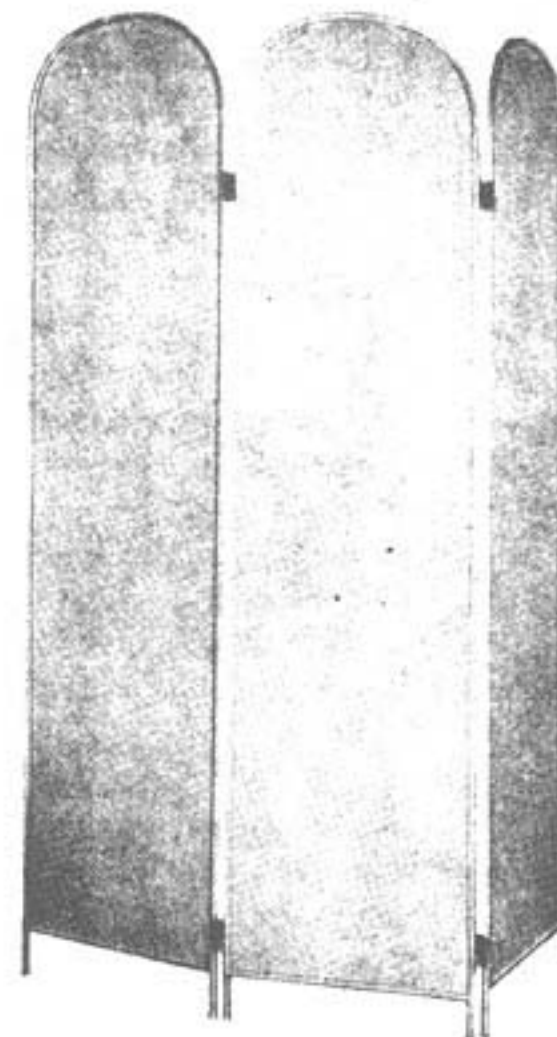


Fig. 3. Frames are of aluminum tubing, panels of stretched silk

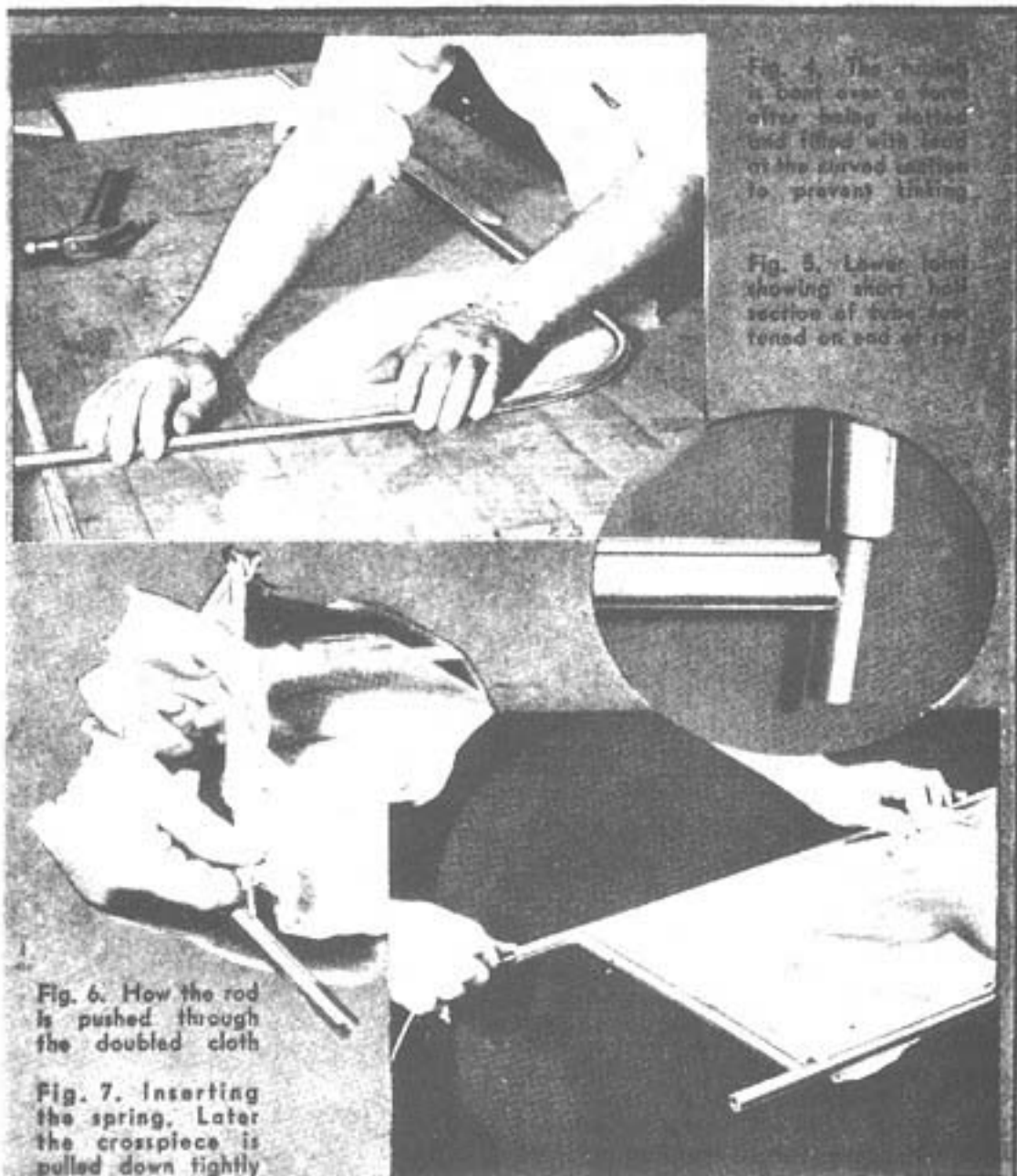


Fig. 4. The tubing is bent over a form after being slotted and filled with lead on the curved section to prevent kinking

Fig. 5. Lower joint showing short half section of tube fastened on end of rod

Fig. 6. How the rod is pushed through the doubled cloth

Fig. 7. Inserting the spring. Later the crosspiece is pulled down tightly



801. Lint, how made. This may be quickly made by nailing a piece of old linen on a board, and scraping its surface with a knife. It is used either alone or spread with ointment. Scraped lint is the fine filaments from ordinary lint, and is used to stimulate ulcers and absorb discharges; it is what the French call *charpie*.

802. Uses of Scraped Lint. This is made into various shapes for particular purposes. When it is screwed up into a conical or wedge-like shape, it is called a *tent*, and is used to dilate fistulous openings, so as to allow the matter to escape freely; and to plug wounds, so as to promote the formation of a clot of blood, and thus arrest bleeding. When rolled into little balls, called *boulettes*, it is used for absorbing matter in cavities, or blood in wounds. Another useful form is made by rolling a mass of scraped lint into a long roll, and then tying it in the middle with a piece of thread; the middle is then doubled and pushed into a deep-seated wound, so as to press upon the bleeding vessel, while the ends remain loose and assist in forming a clot; or it is used in deep-seated ulcers to absorb the matter and keep the edges apart. This form is called the *bourdonnet*. Another form is called the *pelote*, which is merely a ball of scraped lint tied up in a piece of linen rag, commonly called a dabber. This is used in the treatment of protrusion of the navel in children.

803. Carded Cotton is used as a dressing for superficial burns, and care should be taken to free it from specks, as flies are apt to lay their eggs there, and generate maggots.



Growing Large Grapes

By making use of a method not widely known, fruits of large size can be obtained from trees and vines. The idea is based on certain characteristics of the sap flow in the plants. The sap that contains the plant nourishment goes up in the outer cells of the sap wood; it descends late in the season, not through the same cells but through the large so-called sieve cells of the inner bark.

A prize-winning bunch of grapes was produced by an application of this knowledge in the following manner: The grower first selected a perfect bunch of grapes growing from a good, strong cane; next, he cut off all bunches above it on the same cane, and just below the selected cluster the cane was girdled, the bark being removed in a band about 1 in. wide.

How to Make Hammocks

Popular Mechanics 1919

PART I—A Twine Hammock

CORD hammocks may be made in two or more different ways, the knots being formed by the simple overhand tie, Fig. 1; the flat reef knot, Fig. 2; the Solomon's knot, Fig. 3, or by the triple throw-over, Fig. 4; or they can be knotted by the process known as netting, Fig. 5, in which a special needle, or shuttle, is used.

In using any one of the first three methods of making the knots it is necessary to have cords arranged in pairs and long enough to reach from one end of the hammock to the other, allowing only sufficient length for the take-up in tying the knots and the spread of the meshes. The overhand knot is large, and the Solomon's knot is a little unwieldy, but is considered more beautiful when tied. The flat reef knot is small, is easily tied and will not slip. The netting process has a good knot and has the advantage of a short single cord, as the meshes are made independently and the cord is carried on the netting needle.

It is a great advantage, when making a hammock with the simple overhand, the flat reef, or the Solomon's knot, to loop all the pairs of cords at the center about a rod, Fig. 6—which may be any stick such as an old broom handle—knotting from the center to-

ward each end, one side being tied, and then the other. When the first pairs are being tied, the opposite ends should be looped up together out of the way. Even half the length of a hammock makes a long cord to be drawn through each time a knot is tied, and each string can be wound about the fingers into a little bundle and secured with a half hitch, using the same cord, and left hanging, as shown in Fig. 7, allowing sufficient cord free to throw large loops in the tying, and to make about 10 additional meshes. About 3 ft. would be a good length to be left free.

It will be necessary to have 24 pairs of cords—48 cords in all—each 18 ft. long to make a hammock by the first two methods of tying the knots. Seine twine of medium-hard twist and 24-ply can be obtained from a store carrying sporting goods, and is about the best material to use for this purpose.

When these pairs of cords are looped on the center rod, and the rod has been anchored to a wall, as shown in Fig. 8, begin by placing the mesh stick, or rather the mesh post, Fig. 9, between the first pair of cords, A and B, at the left end of the center rod, as in Fig. 8 and Fig. 6. The simple device illustrated in Fig. 9 is very useful for tying any one of the three first-described knots. The device needs no explanation other than the illustration. It will be seen that there are two sizes on the top of the post; the smaller is for the



When Making a Hammock with the Simple Overhand, Flat Reef, or Solomon's Knot, Loop All the Pairs of Cords at the Center about a Rod

Wire Mesh Used as a Shelf From Popular Mechanics 1915

In covering a window back of my lathe with wire mesh as a protection I also made a shelf for the tools between the window sill and the lathe bed of the same material. The mesh used was $\frac{1}{4}$ -in. The shelf is always clean, as the shavings and dirt fall through, and the tools may be readily picked up.

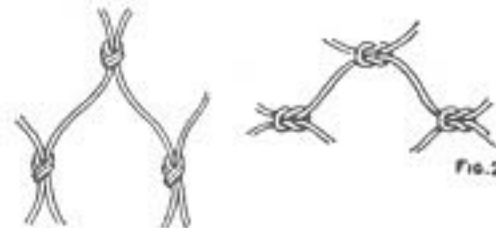


Fig. 1

Fig. 2

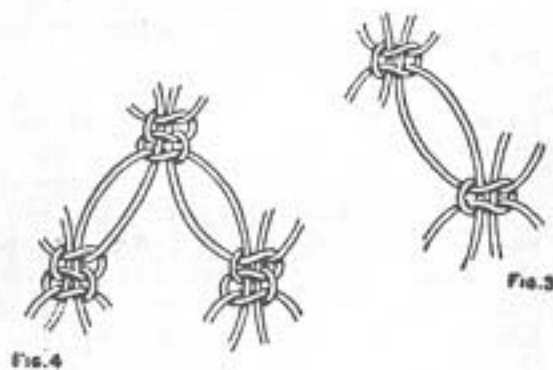


Fig. 3

Fig. 5

The Simple Overhand, Flat Reef, Solomon's Knot, Triple Throw-Over, and Netting Ties

first time across only. The mesh post should be of convenient height for a person when sitting on an ordinary chair. One foot rests on the base as the tying proceeds, but there is no pulling over, as the tie draws both ways on the post, this also doing away with the pull on the center rod.

The cord to the right, B, is taken in the right hand and thrown over the left cord A, Fig. 8, and is held by the left hand. The left cord A is then tucked down behind the right, as shown in Fig. 10. If the right cord goes over in making the first loop, the same cord B must also go over in the second throw, as in Fig. 11, in order to have a proper square knot that will not slip. The end of A is then tucked under B, as shown by the dotted lines. This makes a very serviceable knot for the hammock, but can be also used for other purposes. The knot is shown in Fig. 2. Draw it up tightly, very hard, for knotting is not worth much if it is not tied well.

In case the simple overhand knot is preferred, the mesh post is placed between the first pair as before, and cords A and B are brought to the front as in Fig. 12, but are carried parallel into a large loop that is thrown over as illustrated, then tucked up through as indicated by the dotted lines. The thumb and first finger of the left hand now slide up to the point P, while the right hand pulls up the loop as it nears the finish, the thumb and first finger crowding the loop down hard against the mesh post. The small part is used for the first row across. The knot formed is shown in Fig. 1.

After tying the first pair of cords, using the knot preferred, slip the first mesh so made off the tying post and place the post between C and D, which is the next, or second, pair. Tie the

second pair and pass on to the third pair, which is E and F. Continue moving and tying until all the 24 pairs of cords have been similarly knotted in their first mesh. The last knotting will be the twenty-fourth pair, which is represented by the cords marked Y and Z. Instead of tying cords of the same pairs on the return trip across, one cord Y of the twenty-fourth pair is tied with one cord X of the twenty-third pair, and the other cord W of the twenty-third pair is tied with the cord V of the twenty-second pair, and so on across the series.

On the second row of tying, the post is first placed between cords Y and X and they are knotted together, but instead of tying about the small part of the post the larger size is used. After cords Y and X have been tied, cords W and V are combined. It will be seen that this is tying the pairs together instead of combining the two cords of the same pair. The third time across the combinations are the same as in the first row. The large mesh is used on all but the first row. The alternations of rows is continued until the cords are tied to within 2½ ft. of the end.

Pull out the center rod, insert it in the second row of meshes, loosen the ends that were looped up and begin the knotting of the opposite ends of the cords. When both sides are completed to within 2½ ft. of the ends, the center rod is removed and inserted in the last row of meshes. Another simple device will be found efficient, which consists of a board, 30 in. long, three or more inches wide and 1 in. thick, with three nails driven in slanting, as shown in Fig. 14, to prevent the ring and rod from slipping off as the tying proceeds. One 2½-in. galvanized ring will be required for each end. The ring is attached to the single nail at the end with a string. This will be found better than just slipping the ring over the nail, as it is necessary to have a little more play in putting the cords through for the tying. The distance from the rod to the ring should be 2 ft. The tie

is made in pairs as before, one cord going under and the other over the side of the ring, using the flat reef knot. There will be a few inches of ends remaining after the tie is made and these are brought back to the main body of the cord and wound with an extra cord used for that purpose. The winding is started by looping the end of the extra cord, or string, about the whole bundle of cord together with the ends, pulling tightly and tying securely with the flat reef knot. This is illustrated in Fig. 15. The winding should be about 1½ in. long where the turned-back ends are cut off. Each time the cord is wound about the bundle it should be



Fig. 12

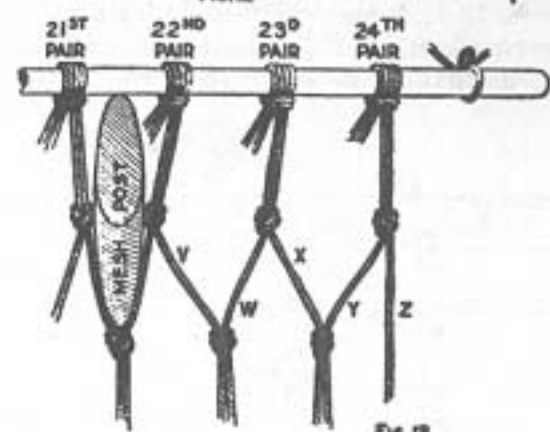


Fig. 13

Tying the Overhand Knot and How to Run the First and Second Rows Across



Fig. 14

Attaching the Rings to the Ends of the Cords and the Binding near the Rings: All the Pairs of Cords are Looped about a Rod in the Center, and the Knots are Made toward the Ends

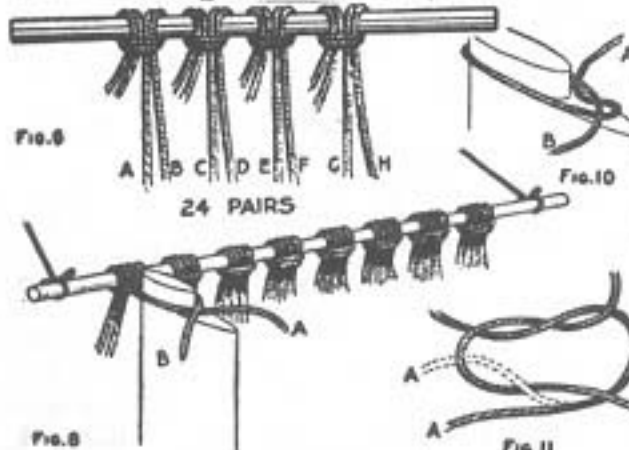


Fig. 6

Fig. 10

24 PAIRS

Fig. 8

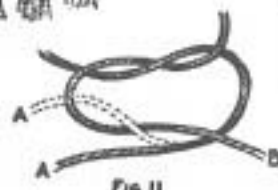


Fig. 11



Fig. 7

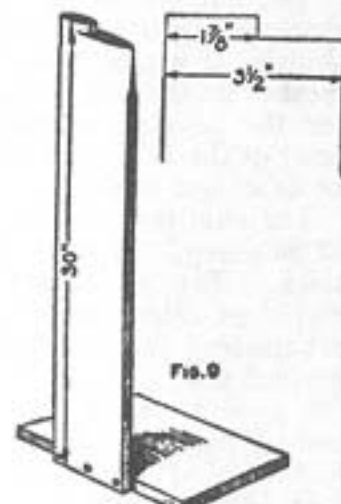


Fig. 9

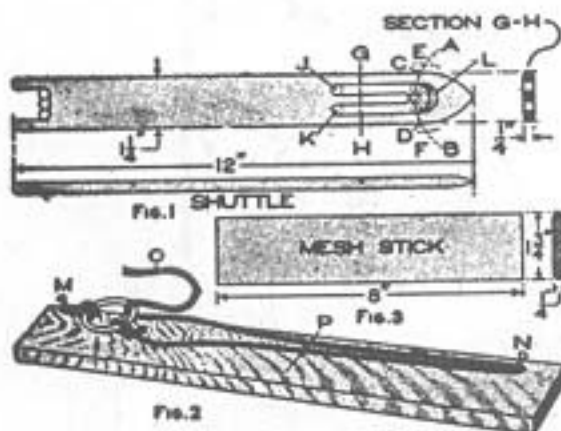
The Mesh Post Has Two Sizes on Its Upper End, the Smaller for Knotting the First Row of Meshes, and the Other for the Remaining Rows. This Illustration Also Shows the Manner of Tying the Knots

looped through its own winding and drawn tightly. This is practically the buttonhole loop. To finish the winding the cord should be given a double looping through its own winding; then with an awl, or other pointed tool, work a way through the under side of the other windings so that the end may be brought out farther back and pulled tightly, to prevent unwinding when the pull comes on the hammock. Attach the ring to the opposite end in the same manner and the hammock is complete.

The edge can be bound the same as a tennis net, or a rope can be run through the outside meshes lengthwise, as desired. A very pretty effect can be obtained by knotting, in a similar manner to the body of the hammock, an apron fringe for the sides.

PART II—A Netted Hammock

A GOOD hammock should be about 12 ft. long, which includes 8 ft. of network and 2 ft., at each end, of long cords that are attached to rings. Seine



The Tools Necessary Consist of a Needle, or Shuttle, a Gauge Board, and a Mesh Stick

twine, of 24-ply, is the best material and it will take 1 1/2 lb. to make a hammock. The twine comes in 1/2-lb. skeins and should be wound into balls to keep it from knotting before the right time. Two galvanized rings, about 2 1/2 in. in diameter, are required.

The equipment for netting a hammock consists of a wood needle, or shuttle, a gauge board for the long meshes at the ends, and a mesh stick for the regular netting of the main body of the hammock, all of which will be described in detail.

The shuttle is made of wood and is 12 in. long, 1 1/4 in. wide, and 1/4 in. thick. The best material to use is maple or other hard wood, but very satisfactory ones can be cut from good-grained pine. The sketch, Fig. 1, shows the general shape of the shuttle, one end being pointed and the other forked. Lay out the pointed end before beginning to cut down to size. Place a compass at the center of the

end, and with a radius of 1 1/2 in. describe the arc AB. With the intersections of this arc and the side lines of the needle, C and D, as centers, and the same radius, 1 1/2 in., cut the arc AB at E and F. With E and F as centers draw the curves of the end of the shuttle. The reason for placing the centers outside of the shuttle lines is to obtain a longer curve to the end. The curves can be drawn free-hand, but will then not be so good.

The space across the needle at GH is divided into five 1/4-in. divisions. The centers of the holes J and K at the base of the tongue are 3 1/2 in. from the pointed end. The opening is 2 3/4 in. long. Bore a 1/4-in. hole at the right end of the opening, and just to the left three holes, as shown by the dotted lines. With a coping saw cut out along the lines and finish with a knife, file, and sandpaper. Round off the edges, as shown by the sectional detail. It is well to bevel the curve at L so that the shuttle will wind easily. The fork is 3/4 in. deep, each prong being 1/4 in. wide. Slant the point of the shuttle and round off all edges throughout and sandpaper smooth.

The gauge board, Fig. 2, is used for making the long meshes at both ends of the hammock. It is a board about 3 ft. long, 4 in. wide, and 1 in. thick. An eight-penny nail is driven into the board 1 in. from the right edge and 2 in. from the end, as shown by M, allowing it to project about 1 in. and slanting a little toward the end; the other nail N will be located later.

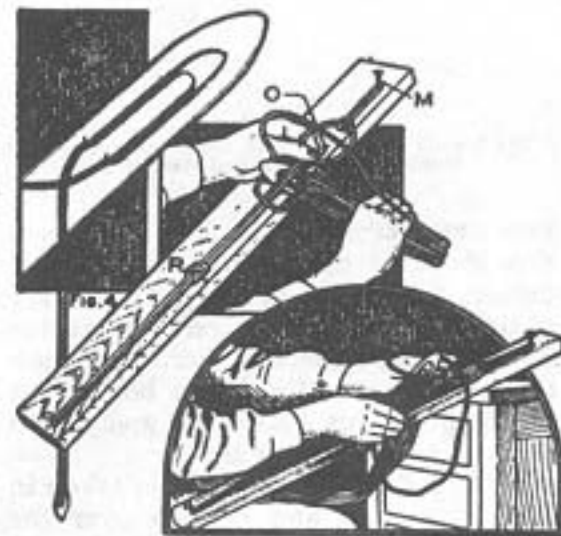
The mesh stick, Fig. 3, should be made of maple, 8 in. long, 1 3/4 in. wide, and 1/4 in. thick. Round off the edges and sandpaper them very smooth.

The making of the net by a specially devised shuttle is called "natting," or netting, when done with a fine thread and a suitably fine shuttle. Much may be done in unique lace-work designs, and when coarser material and larger shuttles are used, such articles as fish nets, tennis nets and hammocks may be made. The old knot used in natting was difficult to learn and there was a knack to it that was easily forgotten, but there is a slight modification of this knot that is quite easy to learn and to make. The modified knot will be the one described.

The shuttle is first wound by looping the cord over the tongue, as shown in Fig. 4, then bringing it down to the forked end and up to the opening on the opposite side; then the cord is again looped over the tongue and returned to the fork or place of starting. Continue winding back and forth until the shuttle is full. The shuttle will accommodate from 20 to 35 complete rounds. If the shuttle is too full it

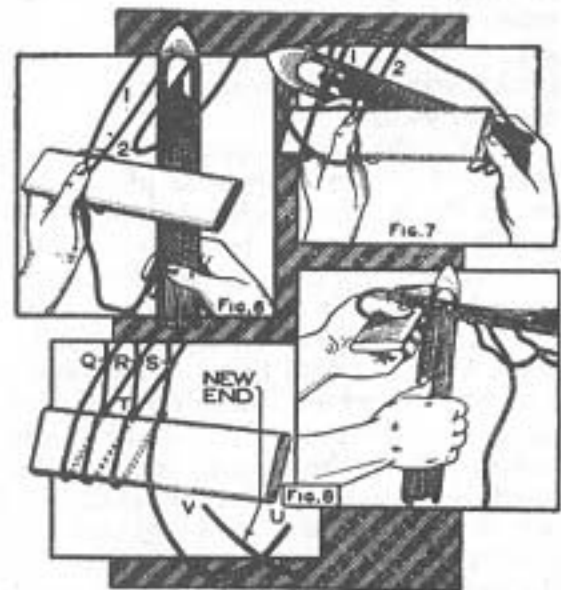
crowds in passing through the meshes and delays the work.

Attach one of the galvanized rings by means of a short cord to the nail in the gauge board, as shown in Fig. 2. At a point 2 ft. from the lower edge of the ring, drive an eight-penny finishing nail, N. Tie the cord end of the shuttle to the ring, bring the shuttle down and around the nail N; then bring it back and pass it through the ring from the under side. The cord will then appear as shown. A part of the ring projects over the edge of the board to make it easier to pass the shuttle through. Draw the cord up tightly



The Shuttle is First Wound and the Long Loops at One End Formed over the Gauge Stick

and put the thumb on top of the cord O, Fig. 5, to prevent it from slipping back, then throw a loop of the cord to the left over the thumb and up over a portion of the ring and pass the shuttle under the two taut cords and bring it up between the thumb and the two



After the Completion of the Long Meshes, the Ring is Anchored and the Mesh Stick Brought into Use

cords, as shown. Draw the looped knot tight under the thumb. Slip the long loop off the nail N and tie a simple

knot at the mark P. This last knot is tied in the long loop to prevent looseness. Proceed with the next loop as with the first and repeat until there are 30 long meshes.

After completing these meshes anchor the ring by its short cord to a hook or other stationary object. The anchorage should be a little above the level for tying the knots of the net. Tie the cord of the shuttle to the left outside loop and always work from the left to the right; and the first time across see that the long meshes do not cross over each other, but are kept in the order in which they are attached to the ring.

After tying the cord to the mesh 1, Fig. 6, bring the mesh stick into use. Pass the cord down over the mesh stick, drawing the lower end of the loop down until it comes against the upper side of the mesh stick and put the thumb down upon it in this position to prevent slipping. Pass the shuttle up through the loop 2 and draw that down to the mesh stick. Shift the thumb from the first position to the second. Throw the cord to the left over the thumb and about the loop 2, as shown in Fig. 7, and bring the shut-

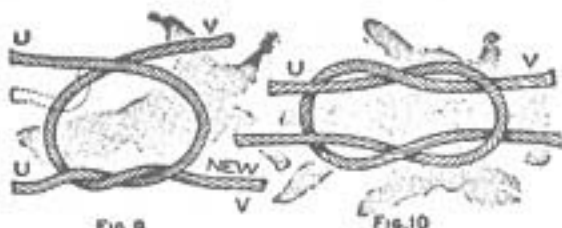
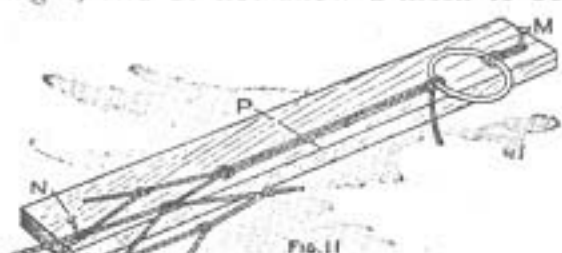


Fig. 9
A Square Knot is Used to Join the Ends of the Cord When Rewinding the Shuttle

tle under both of the cords of mesh 2 and up between the large backward loop and the cords of the mesh 2. Without removing the thumb draw up the knot very tight. This makes the first netting knot. Continue the cord around the mesh stick, pass it up through mesh 3, throw the backward loop, put the shuttle under and up to the left of the mesh 3 and draw very tight, and do not allow a mesh to be



The Gauge Board is Again Used for the Long Loops at the Finishing End, Then the Cords are Wound

drawn down below the upper side of the mesh stick. Some of these cautions are practically repeated, but if a mesh is allowed to get irregular, it will give trouble in future operations.

Continue across the series until all of the long loops have been used and this will bring the work to the right side. Flip the whole thing over, and the cord will be at the left, ready to begin again. Slip all the meshes off the mesh stick. It makes no difference when the meshes are taken off the stick, but they must all come off before a new row is begun. Having the ring attached to the anchorage by a cord makes it easy to flip the work over. Be sure to flip to the right and then to the left alternately to prevent the twisting, which would result if turned one way all the time.

The first mesh each time across is just a little different problem from all the others, which may be better understood by reference to Fig. 8. The knots Q, R, and S are of the next previous series. The cord is brought down over the mesh stick and up through mesh 1, and when the loop is brought down it may not draw to the mesh stick at its center; it is apt to do otherwise and a sideway pull is necessary, which is pulled so that the knots Q and R are side by side, then the knot at T may be tied. When the mesh 2 is drawn down it should pull to place without shifting, and also all the others of that row.

With a piece of cord about six feet long, start quite close to the ring and wind all the cords of the long loops together. The winding should be made very tight, and it is best to loop under with each coil. This is shown in Fig. 12.

The hammock is now ready for use. Some like a soft, small rope run through the outside edges lengthwise, others prefer a fringe, and either can be added. The fringe can be attached about six meshes down from the upper edge of the sides. The hammock should have a stretcher at each end of the netted portion, but not as long as those required for web hammocks.

Continue the use of the mesh stick until a net 8 ft. long is made. When the cord gives out rewind the shuttle and tie with a small knot that will not slip. The weaver's knot is good if known, or the simple square knot shown in Fig. 9 is very good. It is too easy to make to need direction, but unless it is thrown over just right it will slip. Let U, Fig. 8, represent the short cord and V the new piece to be added. Place the cord V back of U and give U a complete turn around V, Fig. 9, and bring them together at a point above U, then to the front. Repeat the com-

plete turn of U about V, shown by the dotted line, and pull tightly. If analyzed, it consists of two loops that are just alike and linked together as shown in Fig. 10.

When the 8 ft. of netting has been completed, proceed to make the long loops as at the beginning. The same gauge board can be used, but the tying occurs at both ends, and since the pairs cannot be knotted in the center, two or three twists can be given by the second about the first of each pair. The long loops and the net are attached together as shown in Fig. 11. Slip one of the meshes of the last run over the nail N, and when the cord comes down from the ring, the shuttle passes through the same mesh, and when drawn up, the farthest point of the mesh comes against the nail. After this long loop has been secured at the ring, the first mesh is slipped off and the next put on. All of the long loops at this end will be about three inches shorter than at the other end, unless the finishing nail N is moved down. This will not be necessary.

SAFETY

CHOPPING BLOCK

From Popular Mech. 1919

Chopping of pieces of wood, which must be broken into short lengths, is often dangerous. The chopping block shown in the illustration was designed to overcome this element of danger and it may be used for chopping small kindling wood as well as for breaking up heavier pieces. When the blow is struck on the wood to be broken the pieces are thrown away from the person chopping. The sketch shows the device in use for the chopping of short pieces of wood, and the heavy portion may be used as a seat. The smaller sketch shows how the block is built up of 2-in. planks, bolted together.

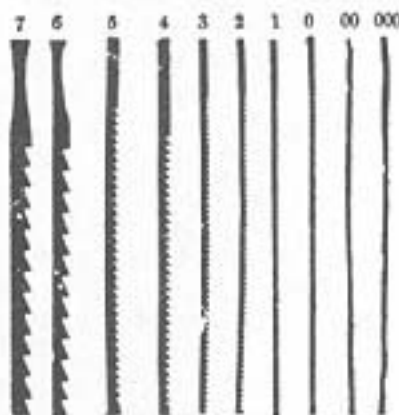


This Chopping Block Makes for Safety in That Pieces Chopped are Thrown Away from the Worker

FRET SAWING AND WOODCARVING

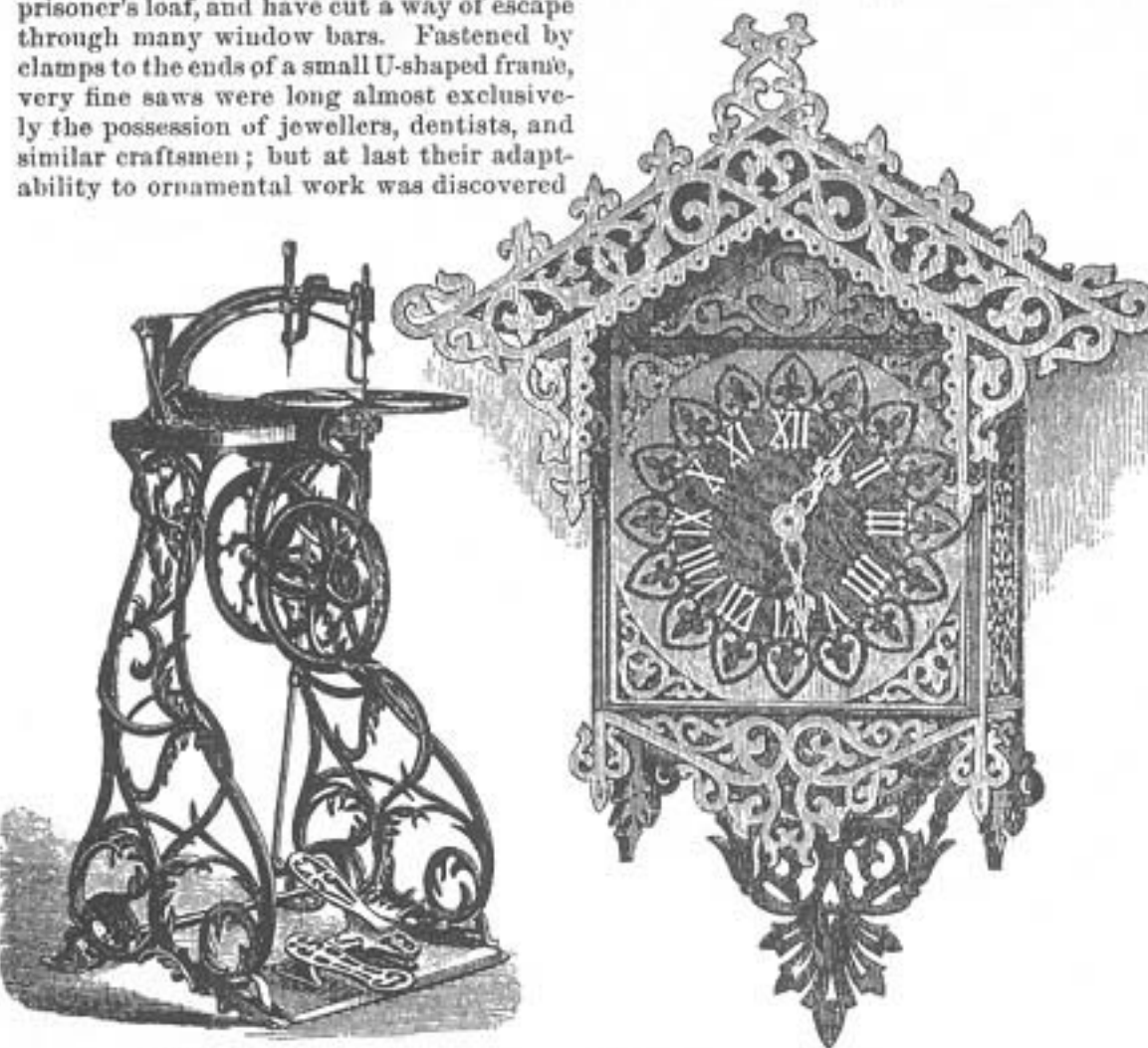
THE two most familiar tools are the knife and the saw, and the cutting edge of the one and the scratching edge of the other are the working part of all our implements, except the plough and some others which make a simple application of the wedge in splitting. The drawing cut, the scratching cut, and the pressing or separating cut are the three motions; the knife or cutting edge with which we make a drawing cut, or, as always with the plane, a pushing cut, is really a saw with invisible teeth, and scratches its way, the forward or pushing being in effect the same as the other. Thus, drawing the blade scratches with the point of the V-shaped tooth; pressing straight forward scratches with the side of the tooth, working like the scissors cut of the mowing-machine. Theoretically, therefore, every knife is a saw, and the saw is the universal tool, its tooth varying from a size beyond the microscope to that of the monster "circular."

The fret or "jig" saw is an old and well-known tool in cabinet-making, and a familiar example of its work is the music rack of the piano or the reed organ. Small saws, fabricated sometimes from watch springs, are a favorite tool for concealment in the prisoner's loaf, and have cut a way of escape through many window bars. Fastened by clamps to the ends of a small U-shaped frame, very fine saws were long almost exclusively the possession of jewellers, dentists, and similar craftsmen; but at last their adaptability to ornamental work was discovered



SAW BLADES.

will therefore attempt to give direction to, as well as awaken an interest in, sawing and in its cognate but broader art, wood-carving. The saw blade itself has undergone no change. The illustration shows it full-sized, a little less than one-half length. The finest blades have teeth scarcely visible to the eye, and make a cut scarcely thicker than a leaf of this Magazine; none of them have any "set," and they are never sharpened, their natural end



THE SAWING-MACHINE.

SAWED CLOCK, IN HERRING-EYE MAPLE, EBONY, MOTTLED WALNUT, AND IVORY.

The first practical and efficient machine for sawing originated in this country.

The present article, which can hardly do more than drop hints,

being breakage. Their smallness is not so remarkable as that of watch screws, some of which to the unaided eye show

neither head nor thread; but they are marvels of cheapness.



SAWED WALL-POCKET.

The simplest form of holder for the saw is the U-shaped hand frame of wood or steel, the latter being the best.

Its cheapness is

all that commends it, for its capacities are very restricted, its work being slow and laborious as compared with the treadle machines. Inlaying and mosaic work can not be successfully done with it, and those who wish to produce the most artistic results possible must use a first-class treadle machine, yet the hand frame will remain the tool for boys, and is excellent for beginners. As good work can not be done with a treadle machine unless it is well planned and well made, so that its parts are nicely fitted, and move with ease, smoothness, and accuracy, the sale of so many coarse and badly fitted wooden machines is much to be regretted. If the amateur can not afford the cost of a first-class machine, ranging from \$6 to \$25, he will do better to buy the best fifteen-inch steel bow frame he can find, costing about \$1 50, and let patience and skill offset as far as they can the defectiveness of his tools, remembering that the work, when success in the commercial sense is not sought, is in the workman rather than the tools.



PICTURE-FRAME.

In the cabinet-maker's hands the saw produces only variations of the familiar "scroll" in wood from half an inch to several inches thick; in the hands of the amateur it is confined to thinner stuff, generally from one-sixteenth to three-sixteenths, and seldom exceeding one-half inch, but becomes a tool which cuts with facility leaves, figures, vines, and every thing which ingenuity can devise, the delicacy and intricacy of the work being scarcely limited except by the skill and patience of the workman. Beginning with the brackets with which the boy always begins, designers have produced patterns

for book racks, screens, easels, wall-pockets, clocks, fancy boxes, photograph frames, vases, thermometer stands, and many others, ingenuity being taxed as constantly to find new applications as new patterns. The saw can cut only in a vertical line, and always through the wood, just as the sewing-machine can make only one stitch, and al-

ways through and through the cloth. This seemed at first a very restricted capacity, but ingenuity soon discovered how to make it answer for all work except button-holes, and ingenuity will probably in like manner enlarge the applications of the saw to purposes of ornament. That is, however, strictly limited to cutting on parallel sides with straight edges. It is not a carving tool; it can not paint a picture, except in profile; it cuts out natural objects in silhouette. Yet the practical effectiveness of this repetition of silhouettes is far greater than the superficial observer would suppose; it rests entirely in the thought, skill, and taste of the workman.

A further step in the decorative use of the saw is "overlaying." This consists of simply cutting out a design in some thin stuff—ordinary veneers being generally used—and gluing the figure to a thicker piece, which serves as a ground, woods of contrasting colors, of course, being chosen. "Paper" veneers in fancy woods are furnished for this purpose, which are not thicker than stout paper, and are glued to a paper backing, this backing remaining on the cut figure, and holding it together. Overlaying may therefore be used as a ready means of ornamenting panels and the like, although the idea will disturb the severe art critic, who hates veneer, and can abide nothing short of solid substance. This is not the place for a discussion of the question, but does the just objection to veneer lie in the fact that it is a shell? There is no cheat, for there is no pretense of solidity; and when the superficial nature of the beauty is known and not denied, wherein is the eye harmed by the sight of veneering and plating? If every body could only have rose-wood and silver solid, well and good. As this can not be, the eye sees in the shaving exactly all it could see in the substance, for beauty is but skin-deep, and form and finish are its real tests. Is not the just abhorrence of veneering really an abhorrence of a certain tawdriness, a dishonest copying of genuine art forms, a cheap and lying trickiness which means to deceive, and works only to sell? If veneering is regarded as the type of this lying in life and manners, may the abhorrence of it never be less!

But decidedly the most beautiful, most artistic, and most promising work of the saw is inlaying and mosaic. In its simplest example inlaying consists of pinning together two pieces of wood of strong contrasting colors—say, walnut and holly—laying the design on top, and cutting both pieces at once. The corresponding pieces in the two woods are then interchanged and glued fast, the pattern thus being reproduced in duplicate, one being a white figure on a dark ground, and the other a dark figure on a white ground.

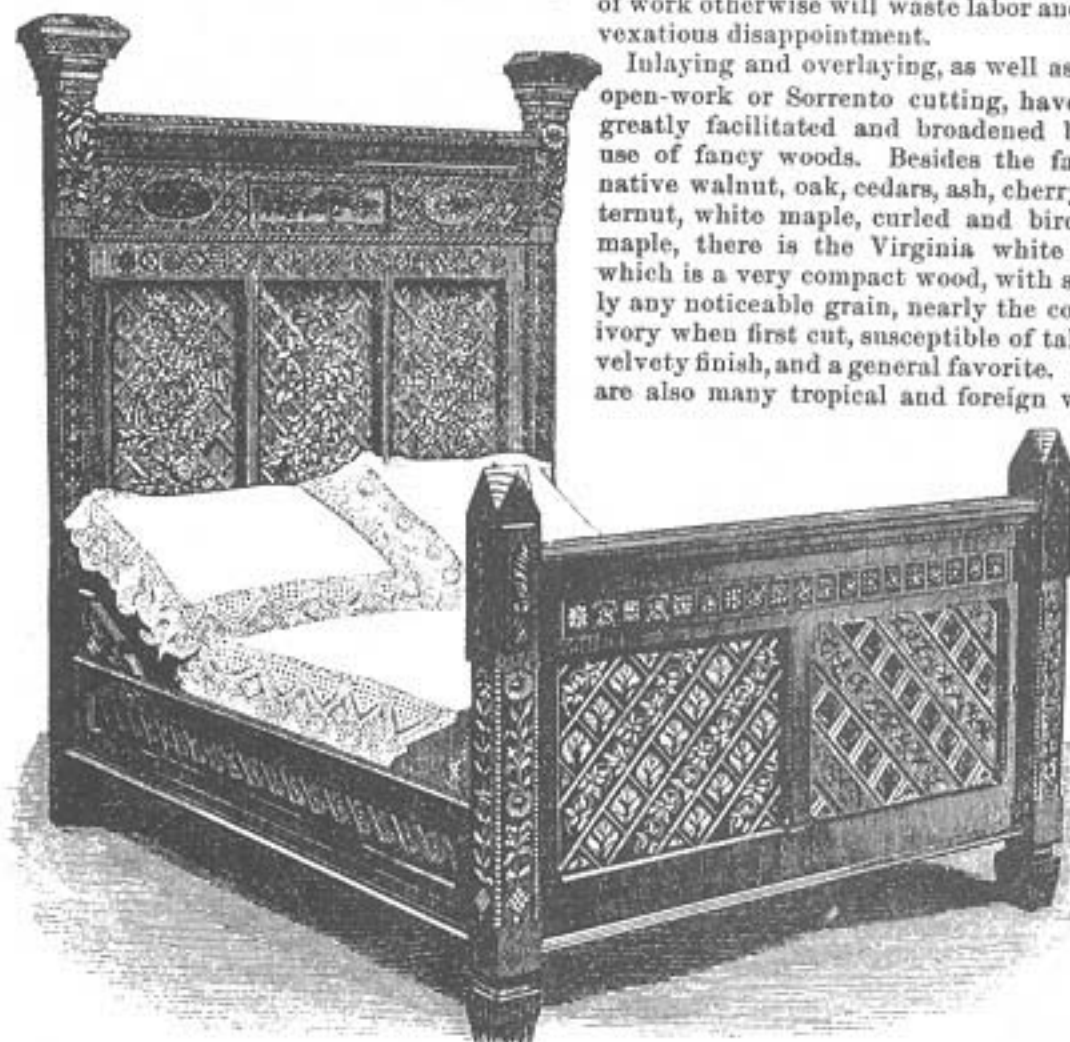
If cut "straight"—that is, with the wood lying so that the saw works in a line perpendicular to it—a number of inlays can be made at a time. Very thin and fine saws, however, must in that case be used, and the kerf must be filled with glue. By using a "beveling" attachment, which tilts the

work-table up at any desired angle with the saw, the pieces cut out become wedge-shaped, thus compensating for the saw kerf. Stronger saw blades can thus be used, and a much tighter fitting of the pieces effected. If the work is skillfully done, the joints are invisible, and the effect is that of a painted panel. This is working in colors, and of course the only limitation is that of the variety of colors obtainable in natural woods, unless the brush is used to touch and supple-

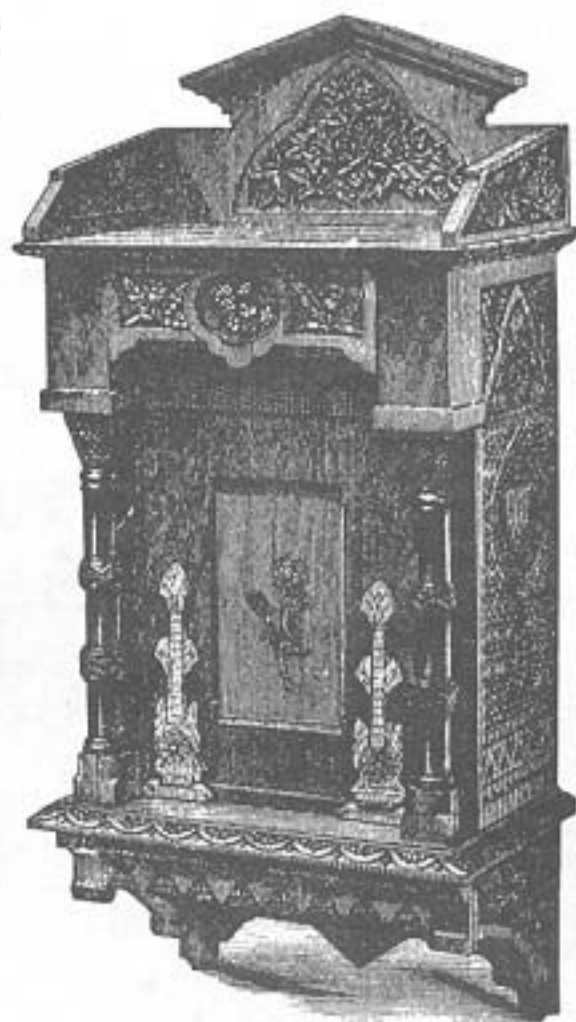


INLAY-WORK.

ment. Rose-wood and cocobola, for example, may be made to imitate pretty closely the irregular splashes of color on the oak or maple leaf in autumn; and there is no limit to the number of successive inlays which can be used, overlapping and blending with one another. Table-tops, book-cases, and other articles of furniture can be tastefully ornamented by overlaying or by inlaying; but as the greatest accuracy and nicety of cut are essential, only the best treadle machines and the best materials can be successfully



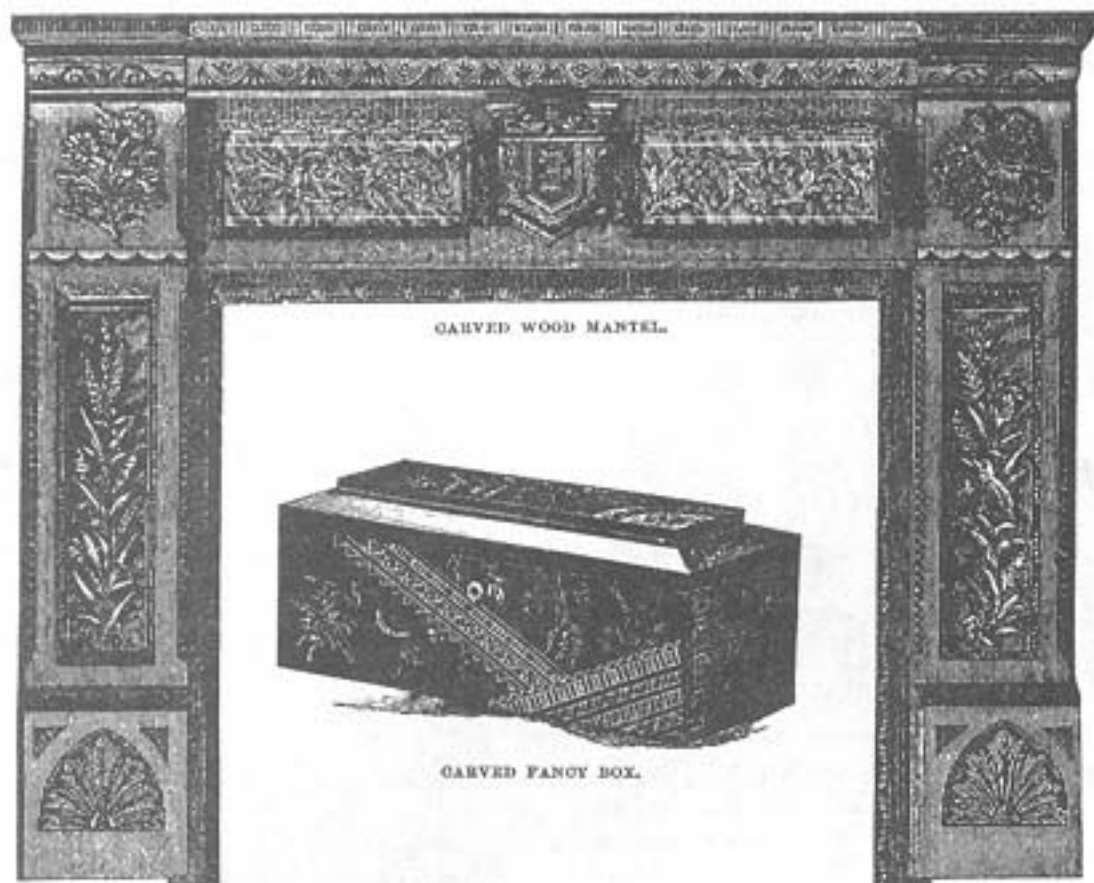
CARVED BEDSTEAD.



CARVED HANGING CABINET.

used. The amateur who attempts this class of work otherwise will waste labor and meet vexatious disappointment.

Inlaying and overlaying, as well as plain open-work or Sorrento cutting, have been greatly facilitated and broadened by the use of fancy woods. Besides the familiar native walnut, oak, cedars, ash, cherry, butternut, white maple, curled and bird's-eye maple, there is the Virginia white holly, which is a very compact wood, with scarcely any noticeable grain, nearly the color of ivory when first cut, susceptible of taking a velvety finish, and a general favorite. There are also many tropical and foreign woods,



CARVED WOOD MANTEL.

CARVED FANCY BOX.

such as mahogany, rose-wood, satin-wood, cocobola, ebony, tulip, amboyua, camino, amaranth, thuya, snake, zebra, camphor, Hungarian ash, etc. Some of these are singular. Snake is of extraordinary hardness,



BRACKET.

found only in narrow slips, and almost an exact copy of a snake's spotted skin; amaranth is of a rich red color; cocobola and tulip are also red, but variegated; Hungarian ash is a figured wood, its stripes and spots suggesting a tiger's coat; walnut burla are marked with rings and spots resembling the "eyes" in a peacock's tail. All these are procurable, planed to a uniform thickness, from one-sixteenth to one-quarter of an inch, smoothly finished on both sides, and ready for use. Brass, nickel, pearl, tortoise-shell, ivory, silver, gold, hard India rubber, and other rare materials are available for the

use of those who wish to follow decorative work to its most artistic results. For the choicest work the originality of the enthusiast may assert itself, and may be left to produce special designs, which, whatever their intrinsic merit, will have for himself an especial pleasure. For a single hint in fret-



BRACKET.

cutting this may suffice: a design embracing many details of slender and delicate work, wrought in thin wood—say, one-sixteenth of an inch—then backed with a ground of silk or velvet of strong color, and

the table thus made let into the cover of a book or album, forms a charming novelty in binding.

Buhl-work—named from André C. Boule, a French carver, born in 1642 and died in 1732—consists of a design cut in gold, silver, brass, or other metal, and let into



PARTS OF A BOX, INLAID.

ivory, ebony, tortoise-shell, etc. Marquetry is another name for inlaying. In each, as in plain open-cut work, the variety and tastefulness of the possible decoration are scarcely limited except by the skill, versatility, and patience of the workman. For example, the variety in color, which seems to be severely restricted by the natural hues of the wood, may be considerably enlarged by several little devices, of which I will mention one: a light-colored wood, especially holly, may be darkened or browned by dipping it in heated sand; if done with nicety, a graduated shading, which serves well to imitate the shadow of raised objects in painting, may be thus produced.

Wood-carving is an old art and a hackneyed subject. To treat it exhaustively would require a volume; hence I attempt nothing more than a suggestive sketch of it as related to the saw, and as adapted in this country to purposes of culture and home decoration. The wood-carver is a sculptor in wood, and after he leaves

the flat surface beyond which the saw can not go, he has a field of indefinite breadth before him. He needs for adjuncts a vise or a wooden screw for holding his material firmly, leaving his hands free; also hones, sand-paper, cement, sweet-oil, pencils of rather a soft quality, screws, a pair of leather gloves, and some wash-leather, mallets, and files. His cutting tools are about a score in number, consisting of chisels, both straight and bent, with edges varying from one-eighth to three-quarters of an inch in width; gouges with edges from this shape (U) to this (V); chisels with bevelled edges; and dividing tools with edges shaped like a broad letter V. Patience, care, and unflagging enthusiasm are necessary for the amateur's success; these must be aided by tools of the best quality, kept in the best condition, as a



PAPER-CUTTERS.



CROSS.



CARVED BRACKET.

dull tool may suddenly spoil the fruit of long labor.

The learner may try his hand on simple ornamentation of sawed work, and he will probably not use the saw very long before doing so. A simple beginning consists in cutting the veins and rounding the twigs and berries in sawed work. Some knowledge of drawing is of course necessary, and the learner who contemplates going far will do wisely to seek the help of a competent instructor.



CARVED WALL-POCKET.



Unions pricing selves out of job market

Jack
Mabley

Chicago Tribune March 7, 1978

TO PUT AN electrician out on a job, Harvey T. Nack, owner of White City Electric Co., starts with the union pay of \$11.75 an hour. Then he adds 43 per cent for insurance, health plans, vacations, holidays, and taxes, bringing his labor cost to \$16.80 an hour.

Then he adds 20 per cent for overhead—like equipment, trucks, office equipment, utilities, and other expenses. His cost per man is \$20.16 an hour before he or his company makes a dime for profit or expansion.

Nack is in construction work, but companies that service homes have similar costs. This might help explain those horrendous bills we get when we have to send for help to fix a plugged drain or a shorted wire or a busted furnace.

Nack talked with us because he sees two consequences of the escalating costs: He and his colleagues are pricing themselves out of the market, and non-union labor is proliferating.

NOBODY IN THE business wants to make unions mad. The nonunion work is called "underground industry" or "secondary construction market," or in specific areas, "merit shop."

Nack cites the heavy increase in production and sales of electrical supplies.

"They've risen about three times faster than the number of construction hours worked by union employees," he says.

"The two should go together, but they don't. Ten or 12 years ago, 72 to 80 per cent of material sold was installed by electrical contractors. Now it's only 41 or 42 per cent.

"Somebody's putting that other stuff in."

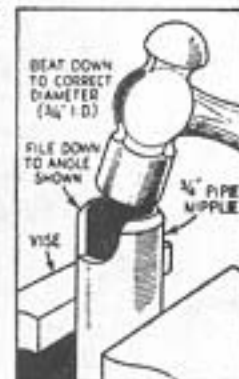
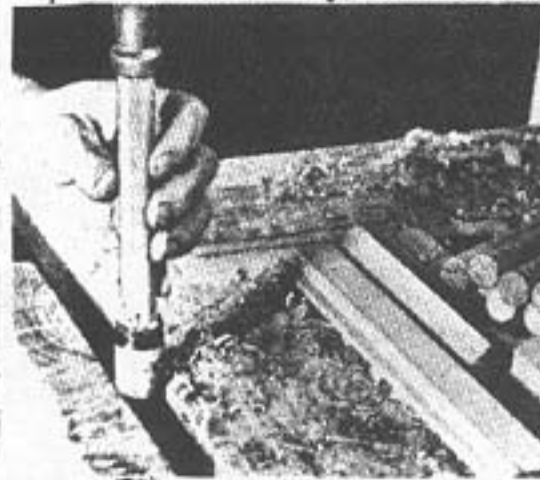
Nack has a friend who runs an "underground" company.

"You'd never know they were there," he says. "But they'll do anything you want. The men are good workers who want a job but can't get a union job. If they're willing to take \$5.60 an hour

DOWELS SHAPED WITH SHARPENED PIPE

SCRAPS of wood can be made into dowels of any desired size with a tool formed from a pipe nipple or short piece of pipe. In the case illustrated, $\frac{3}{4}$ -in. dow-

Popular Science Monthly, November 1936



The dowel-making tool and, at left, how the rough stock is driven through

els were needed, so a pipe of approximately $\frac{3}{4}$ -in. inside diameter was used. File one end of the nipple to the angle shown in the sketch, hammer in the filed

edge until it measures exactly the desired size, and grip the pipe vertically in the vise. Rip short lengths of stock for the dowels to $\frac{3}{4}$ in. square, or whatever size is wanted, and then dress off the corners to form an octagon shape. If the wood is hard, plane off the eight corners to make the stock more nearly round before driving it through.

—R. O. LISSAMAN.

DOG'S BARK TONED DOWN BY OPERATION

Popular Science Monthly, November 1936



An Atlanta, Ga., veterinarian cutting a slice out of a dog's vocal cord. This painless operation is said to muffle the animal's bark

TONING DOWN the barking of noisy dogs is the reported accomplishment of an Atlanta, Ga., veterinarian, who has performed the feat upon the pets of a number of apartment dwellers. In the simple, painless operation that he has devised, a dog's vocal cord is relieved of a small V-shaped wedge on either side. No danger to the animal is involved, it is said, and the only after effect is that an ear-splitting bark is muffled to a dulcet tone that can cause no complaints from neighbors. In the photo at left, a pet is under treatment.

with five holidays and a little vacation and some hospitalization—if they want to do it, then why not?"

WE TALKED WITH a man who runs a merit shop in the outlying suburbs.

"My main objection to unions is they claim all their members are equally skilled and productive," he said. "They say each one is worth \$10 an hour, no more, no less. That isn't true."

His major cost cutter is work flow. He and his men cross jurisdictional lines.

"On a union job an electrician will have to wait around for a carpenter to cut a hole in the ceiling," he said. "Here we just do it. We don't have work stoppages."

"If I pick up a hammer and make a form, I don't have carpenters standing nearby saying, 'Hey, that's my job.'

"If we're doing a \$3,000 electrical job and the guy wants a small closet built, we'll build it for him. A good mechanic is a good mechanic. He can do more than one job."

He also feels that a merit shop is an incentive to faster work.

"All the foremen are on an incentive program, and they usually pass it on," he said. "When a contract is estimated, it's estimated by the norm—an average guy on an average day will do so much work. But a good foreman with a good crew can make those hours look stupid."

He said he works deals with his clients so that if the job is done quicker and cheaper than the estimate, he gets an incentive bonus, which he shares with his employees.

SURVIVOR

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THE PURPOSE OF THIS BOOK

Over 50% of the adult population of the U.S. cannot follow the simplest instructions in this book. Eighty per cent cannot grasp the concepts in the following article by Professor Garrett Hardin.

Our species has outbred the carrying capacity of our planet's easily accessible arable land plus that of their respective socio-economic systems. With overbreeding has come downbreeding. Our planet has become swamped with morons and psychotics which guarantees the collapse of civilizations worldwide

This book is for that intelligent and stable 20%.

CARRYING CAPACITY AS AN ETHICAL CONCEPT

GARRETT HARDIN

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LIFEBOAT ETHICS is merely a special application of the logic of the commons.¹ The classic paradigm is that of a pasture held as common property by a community and governed by the following rules: first, each herdsman may pasture as many cattle as he wishes on the commons; and second, the gain from the growth of cattle accrues to the individual owners of the cattle. In an underpopulated world the system of the commons may do no harm and may even be the most economic way to manage things, since management costs are kept to a minimum. In an overpopulated (or overexploited) world a system of the commons leads to ruin, because each herdsman has more to gain individually by increasing the size of his herd than he has to lose as a single member of the community guilty of lowering the carrying capacity of the environment. Consequently he (with others) overloads the commons.

Even if an individual fully perceives the ultimate consequences of his actions he is most unlikely to act in any other way, for he cannot count on the restraint his conscience might dictate being matched by a similar restraint on the part of *all* the others. (Anything less than all is not enough.) Since mutual ruin is inevitable, it is quite proper to speak of the *tragedy* of the commons.

Tragedy is the price of freedom in the commons. Only by changing to some other system (socialism or private enterprise, for example) can ruin be averted. In other words, in a crowded world survival requires that some freedom be given up. (We have, however, a choice in the freedom to be sacrificed.) Survival is possible under several different politico-economic systems—but not under the system of the commons. When we understand this point, we reject the ideal of distributive justice stated by Karl Marx a century ago, "From each according to his ability, to each according to his needs."² This ideal might be defensible if "needs" were defined by the larger community rather than by the individual (or individual political unit) and if "needs" were *static*.³ But in the past quarter-century, with the best will in the world, some humanitarians have been asserting that rich populations must supply the needs of poor populations even though the recipient populations increase without restraint. At the United Nations conference on population in Bucharest in 1973 spokesmen for the poor nations repeatedly said in effect: "We poor people have the right to reproduce as much as we want

to; you in the rich world have the responsibility of keeping us alive."

Such a Marxian disjunction of rights and responsibilities inevitably tends toward tragic ruin for all. It is almost incredible that this position is supported by thoughtful persons, but it is. How does this come about? In part, I think, because language deceives us. When a disastrous loss of life threatens, people speak of a "crisis," implying that the threat is temporary. More subtle is the implication of quantitative stability built into the pronoun "they" and its relatives. Let me illustrate this point with quantified prototype statements based on two different points of view.

Crisis analysis: "These poor people (1,000,000) are starving, because of a crisis (flood, drought, or the like). How can we refuse *them* (1,000,000)? Let us feed *them* (1,000,000). Once the crisis is past those who are still hungry are few (say 1,000) and there is no further need for our intervention."

Crunch analysis: "Those (1,000,000) who are hungry are reproducing. We send food to *them* (1,010,000). *Their* lives (1,020,000) are saved. But since the environment is still essentially the same, the next year *they* (1,030,000) ask for more food. We send it to *them* (1,045,000); and the next year *they* (1,068,000) ask for still more. Since the need has not gone away, it is a mistake to speak of a passing crisis: it is evidently a permanent crunch that this growing "they" face—a growing disaster, not a passing state of affairs."

"They" increases in size. Rhetoric makes no allowance for a ballooning pronoun. Thus we can easily be deceived by language. We cannot deal adequately with ethical questions if we ignore quantitative matters. This attitude has been rejected by James Sellers, who dismisses prophets of doom from Malthus⁴ to Meadows⁵ as "chiliasts." Chiliasts (or millennialists, to use the Latin-derived equivalent of the Greek term) predict a catastrophic end of things a thousand years from some reference point. The classic example is the prediction of Judgment Day in the year 1000 anno Domini. Those who predicted it were wrong, of course; but the fact that this specific prediction was wrong is no valid criticism of the use of numbers in thinking. Millennialism is numerology, not science.

In science, most of the time, it is not so much exact numbers that are important as it is the relative size of numbers and the direction of change in the magnitude of them. Much productive analysis is accomplished with only the crude quantitation of "order of magnitude" thinking. First and second derivatives are often calculated with no finer aim than to find out if they are positive or negative. Survival can hinge on the crude issue of the sign of change, regardless of number. This is a far cry from the spurious precision of numerology. Unfortunately the chasm between the "two cultures," as C. P. Snow called them,⁶ keeps many in the non-scientific culture from understanding the significance of the quantitative approach. One is tempted to won-

der also whether an additional impediment to understanding may not be the mortal sin called Pride, which some theologians regard as the mother of all sins.

Returning to Marx, it is obvious that the *each* in "to each according to his needs" is not—despite the grammar—a unitary, stable entity: "each" is a place-holder for a ballooning variable. Before we commit ourselves to saving the life of *each* and every person in need we had better ask this question: "And then what?" That is, what about tomorrow, what about posterity? As Hans Jonas has pointed out,⁷ traditional ethics has almost entirely ignored the claims of posterity. In an overpopulated world humanity cannot long endure under a regime governed by posterity-blind ethics. It is the essence of ecological ethics that it pays attention to posterity.

Since "helping" starving people requires that we who are rich give up some of our wealth, any refusal to do so is almost sure to be attributed to selfishness. Selfishness there may be, but focusing on selfishness is likely to be non-productive. In truth, a selfish motive can be found in all policy proposals. The selfishness of *not* giving is obvious and need not be elaborated. But the selfishness of giving is no less real, though more subtle.⁸ Consider the sources of support for Public Law 480, the act of Congress under which surplus foods were given to poor countries, or sold to them at bargain prices ("concessionary terms" is the euphemism). Why did we give food away? Conventional wisdom says it was because we momentarily transcended our normal selfishness. Is that the whole story?

It is not. The "we" of the above sentence needs to be subdivided. The farmers who grew the grain did not give it away. They sold it to the government (which then gave it away). Farmers received selfish benefits in two ways: the direct sale of grain, and the economic support to farm prices given by this governmental purchase in an otherwise free market. The operation of P. L. 480 during the past quarter-century brought American farmers to a level of prosperity never known before.

Who else benefited—in a selfish way? The stockholders and employees of the railroads that moved grain to seaports benefited. So also did freight-boat operators (U. S. "bottoms" were specified by law). So also did grain elevator operators. So also did agricultural research scientists who were financially supported in a burgeoning but futile effort "to feed a hungry world."⁹ And so also did the large bureaucracy required to keep the P. L. 480 system working. In toto, probably several million people personally benefited from the P. L. 480 program. Their labors cannot be called wholly selfless.

Who *did* make a sacrifice for P. L. 480? The citizens generally, nearly two hundred million of them, paying directly or indirectly through taxes. But each of these many millions lost only a little: whereas each of the million or so gainers gained a great deal. The blunt truth is that *philanthropy pays*—if you are hired as a philanthropist. Those on the gaining side of P.L. 480 made a great deal of money and could afford to spend lavishly to persuade Congress to continue the program. Those on the sacrificing side sacrificed only a little bit per capita and could not afford to spend much protecting their pocketbooks against philanthropic inroads. And so P. L. 480 continued, year after year.

Should we condemn philanthropy when we discover that some of its roots are selfish? I think not, otherwise probably no philanthropy would be possible. The secret of practical success in large-scale public philanthropy is this: see to it that the losses are widely distributed so that the per capita loss is small, but

concentrate the gains in a relatively few people so that these few will have the economic power needed to pressure the legislature into supporting the program.

I have spent some time on this issue because I would like to dispose once and for all of condemnatory arguments based on "selfishness." As a matter of principle we should always assume that selfishness is *part* of the motivation of every action. But what of it? If Smith proposes a certain public policy, it is far more important to know whether the policy will do public harm or public good than it is to know whether Smith's motives are selfish or selfless. Consequences ("ends") can be more objectively determined than motivations ("means"). Situational ethics wisely uses consequences as the measure of morality. "If the end does not justify the means, what does?" asks Joseph Fletcher.¹⁰ The obsession of older ethical systems with means and motives is no doubt in part a consequence of envy, which has a thousand disguises.¹¹ (Though I am sure this is true, the situationist should not dwell on envy very long, for it is after all only a motive, and as such not directly verifiable. In any case public policy must be primarily concerned with consequences.)

Even judging an act by its consequences is not easy. We are limited by the basic theorem of ecology, "We can never do merely one thing."¹² The fact that an act has many consequences is all the more reason for de-emphasizing motives as we carry out our ethical analyses. Motives by definition apply only to intended consequences. The multitudinous unintended ones are commonly denigrated by the term "side-effects." But "The road to hell is paved with good intentions," so let's have done with motivational evaluations of public policy.

Even after we have agreed to eschew motivational analysis, foreign aid is a tough nut to crack. The literature is large and contradictory, but it all points to the inescapable conclusion that a quarter of a century of earnest effort has not conquered world poverty. To many observers the threat of future disasters is more convincing now than it was a quarter of a century ago—and the disasters are not all in the future either.¹³ Where have we gone wrong in foreign aid?

We wanted to do good, of course. The question, "How can we help a poor country?" seems like a simple question, one that should have a simple answer. Our failure to answer it suggests that the question is not as simple as we thought. The variety of contradictory answers offered is disheartening.

How can we find our way through this thicket? I suggest we take a cue from a mathematician. The great algebraist Karl Jacobi (1804–1851) had a simple stratagem that he recommended to students who found themselves butting their heads against a stone wall. *Umkehren, immer umkehren*—"Invert, always invert." Don't just keep asking the same old question over and over: turn it upside down and ask the opposite question. The answer you get then may not be the one you want, but it may throw useful light on the question you started with.

Let's try a Jacobian inversion of the food/population problem. To sharpen the issue, let us take a particular example, say India. The question we want to answer is, "How can we help India?" But since that approach has repeatedly thrust us against a stone wall, let's pose the Jacobian invert, "How can we *harm* India?" After we've answered this perverse question we will return to the original (and proper) one.

As a matter of method, let us grant ourselves the most malevolent of motives: let us ask, "How can we harm India—*really* harm her?" Of course we might plaster the country with thermo-

nuclear bombs, speedily wiping out most of the 600 million people. But, to the truly malevolent mind, that's not much fun: a dead man is beyond harming. Bacterial warfare could be a bit "better," but not much. No: we want something that will really make India suffer, not merely for a day or a week, but on and on and on. How can we achieve this inhumane goal?

Quite simply: by sending India a bounty of food, year after year. The United States exports about 80 million tons of grain a year. Most of it we sell: the foreign exchange it yields we use for such needed imports as petroleum (38 percent of our oil consumption in 1974), iron ore, bauxite, chromium, tin, etc. But in the pursuit of our malevolent goal let us "unselfishly" tighten our belts, make sacrifices, and do without that foreign exchange. Let us give all 80 million tons of grain to the Indians each year.

On a purely vegetable diet it takes about 400 pounds of grain to keep one person alive and healthy for a year. The 600 million Indians need 120 million tons per year; since their nutrition is less than adequate presumably they are getting a bit less than that now. So the 80 million tons we give them will almost double India's per capita supply of food. With a surplus, Indians can afford to vary their diet by growing some less efficient crops; they can also convert some of the grain into meat (pork and chickens for the Hindus, beef and chickens for the Moslems). The entire nation can then be supplied not only with plenty of calories, but also with an adequate supply of high quality protein. The people's eyes will sparkle, their steps will become more elastic; and they will be capable of more work. "Fatalism" will no doubt diminish. (Much so-called fatalism is merely a consequence of malnutrition.) Indians may even become a bit overweight, though they will still be getting only two-thirds as much food as the average inhabitant of a rich country. Surely—we think—surely a well-fed India would be better off?

Not so: *ceteris paribus*, they will ultimately be worse off. Remember, "We can never do merely one thing." A generous gift of food would have not only nutritional consequences: it would also have political and economic consequences. The difficulty of distributing free food to a poor people is well known. Harbor, storage, and transport inadequacies result in great losses of grain to rats and fungi. Political corruption diverts food from those who need it most to those who are more powerful. More abundant supplies depress free market prices and discourage native farmers from growing food in subsequent years. Research into better ways of agriculture is also discouraged. Why look for better ways to grow food when there is food enough already?

There are replies, of sorts, to all the above points. It may be maintained that all these evils are only temporary ones: in time, organizational sense will be brought into the distributional system and the government will crack down on corruption. Realizing the desirability of producing more food, for export if nothing else, a wise government will subsidize agricultural research in spite of an apparent surplus. Experience does not give much support to this optimistic view, but let us grant the conclusions for the sake of getting on to more important matters. Worse is to come.

The Indian unemployment rate is commonly reckoned at 30 percent, but it is acknowledged that this is a minimum figure. Underemployment is rife. Check into a hotel in Calcutta with four small bags and four bearers will carry your luggage to the room—with another man to carry the key. Custom, and a knowledge of what the traffic will bear, decree this practice. In addition

malnutrition justifies it in part. Adequately fed, half as many men would suffice. So one of the early consequences of achieving a higher level of nutrition in the Indian population would be to increase the number of unemployed.

India needs many things that food will not buy. Food will not diminish the unemployment rate (quite the contrary); nor will it increase the supply of minerals, bicycles, clothes, automobiles, gasoline, schools, books, movies, or television. All these things require energy for their manufacture and maintenance.

Of course, food is a form of energy, but it is convertible to other forms only with great loss; so we are practically justified in considering energy and food as mutually exclusive goods. On this basis the most striking difference between poor and rich countries is not in the food they eat but in the energy they use. On a per capita basis rich countries use about three times as much of the primary foods—grain and the like—as do poor countries. (To a large extent this is because the rich convert much of the grain to more "wasteful" animal meat.) But when it comes to energy, rich countries use ten times as much per capita. (Near the extremes Americans use 60 times as much per person as Indians.) By reasonable standards much of this energy may be wasted (e.g., in the manufacture of "exercycles" for sweating the fat off people who have eaten too much), but a large share of this energy supplies the goods we regard as civilized: effortless transportation, some luxury foods, a variety of sports, clean space-heating, more than adequate clothing, and energy-consuming arts—music, visual arts, electronic auxiliaries, etc. Merely giving food to a people does almost nothing to satisfy the appetite for any of these other goods.

But a well-nourished people is better fitted to try to wrest more energy from its environment. The question then is this: Is the native environment able to furnish more energy? And at what cost?

In India energy is already being gotten from the environment at a fearful cost. In the past two centuries millions of acres of India have been deforested in the struggle for fuel, with the usual environmental degradation. The Vale of Kashmir, once one of the garden spots of the world, has been denuded to such an extent that the hills no longer hold water as they once did, and the springs supplying the famous gardens are drying up. So desperate is the need for charcoal for fuel that the Kashmiri now make it out of tree leaves. This wasteful practice denies the soil of needed organic mulch.

Throughout India, as is well known, cow dung is burned to cook food. The minerals of the dung are not thereby lost, but the ability of dung to improve soil tilth is. Some of the nitrogen in the dung goes off into the air and does not return to Indian soil. Here we see a classic example of the "vicious circle": because Indians are poor they burn dung, depriving the soil of nitrogen and making themselves still poorer the following year. If we give them plenty of food, as they cook this food with cow dung they will lower still more the ability of their land to produce food.

Let us look at another example of this counter-productive behavior. Twenty-five years ago western countries brought food and medicine to Nepal. In the summer of 1974 a disastrous flood struck Bangladesh, killing tens of thousands of people, by government admission. (True losses in that part of the world are always greater than admitted losses.) Was there any connection between feeding Nepal and flooding Bangladesh? Indeed there was, and is.¹⁴

Nepal nestles amongst the Himalayas. Much of its land is

precipitous, and winters are cold. The Nepalese need fuel, which they get from trees. Because more Nepalese are being kept alive now, the demand for timber is escalating. As trees are cut down, the soil under them is washed down the slopes into the rivers that run through India and Bangladesh. Once the absorptive capacity of forest soil is gone, floods rise faster and to higher maxima. The flood of 1974 covered two-thirds of Bangladesh, twice the area of "normal" floods—which themselves are the consequence of deforestation in preceding centuries.

By bringing food and medicine to Nepal we intended only to save lives. But we can never do merely one thing, and the Nepalese lives we saved created a Nepalese energy-famine. The lives we saved from starvation in Nepal a quarter of a century ago were paid for in our time by lives lost to flooding and its attendant evils in Bangladesh. The saying, "Man does not live by bread alone," takes on new meaning.

Still we have not described what may be the worst consequence of a food-only policy: revolution and civil disorder. Many kind-hearted people who support food aid programs solicit the cooperation of "hard-nosed" doubters by arguing that good nutrition is needed for world peace. Starving people will attack others, they say. Nothing could be further from the truth. The monumental studies of Ancel Keys and others have shown that starving people are completely selfish.¹³ They are incapable of cooperating with others; and they are incapable of laying plans for tomorrow and carrying them out. Moreover, modern war is so expensive that even the richest countries can hardly afford it.

The thought that starving people can forcefully wrest subsistence from their richer brothers may appeal to our sense of justice, *but it just ain't so*. Starving people fight only among themselves, and that inefficiently.

So what would happen if we brought ample supplies of food to a population that was still poor in everything else? They would still be incapable of waging war at a distance, but their ability to fight among themselves would be vastly increased. With vigorous, well-nourished bodies and a keen sense of their impoverishment in other things, they would no doubt soon create massive disorder in their own land. Of course, they might create a strong and united country, but what is the probability of that? Remember how much trouble the thirteen colonies had in forming themselves into a United States. Then remember that India is divided by two major religions, many castes, fourteen major languages and a hundred dialects. A partial separation of peoples along religious lines in 1947, at the time of the formation of Pakistan and of independent India, cost untold millions of lives. The budding off of Bangladesh (formerly East Pakistan) from the rest of Pakistan in 1971 cost several million more. All these losses were achieved on a low level of nutrition. The possibilities of blood-letting in a population of 600 million well-nourished people of many languages and religions and no appreciable tradition of cooperation stagger the imagination. Philanthropists with any imagination at all should be stunned by the thought of 600 million well-fed Indians seeking to meet their energy needs from their own resources.

So the answer to our Jacobian question, "How can we harm India?" is clear: send food *only*. Escaping the Jacobian by re-inverting the question we now ask, "How can we *help* India?" Immediately we see that we must *never* send food without a matching gift of non-food energy. But before we go careening off on an intoxicating new program we had better look at some more quantities.

On a per capita basis, India uses the energy equivalent of one barrel of oil per year; the U. S. uses sixty. The world average of all countries, rich and poor, is ten. If we want to bring India only up to the present world average, we would have to send India about 9 x 600 million bbls. of oil per year (or its equivalent in coal, timber, gas or whatever). That would be more than five billion barrels of oil equivalent. What is the chance that we will make such a gift?

Surely it is nearly zero. For scale, note that our total yearly petroleum use is seven billion barrels (of which we import three billion). Of course we use (and have) a great deal of coal too. But these figures should suffice to give a feeling of scale.

More important is the undoubted psychological fact that a fall in income tends to dry up the springs of philanthropy. Despite wide disagreements about the future of energy it is obvious that from now on, for at least the next twenty years and possibly for centuries, our per capita supply of energy is going to fall, year after year. The food we gave in the past was "surplus." By no accounting do we have an energy surplus. In fact, the perceived deficit is rising year by year.

India has about one-third as much land as the United States. She has about three times as much population. If her people-to-land ratio were the same as ours she would have only about seventy million people (instead of 600 million). With the forested and relatively unspoiled farmlands of four centuries ago, seventy million people was probably well within the carrying capacity of the land. Even in today's India, seventy million people could probably make it in comfort and dignity—provided they didn't increase!

To send food only to a country already populated beyond the carrying capacity of its land is to collaborate in the further destruction of the land and the further impoverishment of its people.

Food plus energy is a recommendable policy; but for a large population under today's conditions this policy is defensible only by the logic of the old saying, "If wishes were horses, beggars would ride." The fantastic amount of energy needed for such a program is simply not in view. (We have mentioned nothing of the equally monumental "infrastructure" of political, technological, and educational machinery needed to handle unfamiliar forms and quantities of energy in the poor countries. In a short span of time this infrastructure is as difficult to bring into being as is an abundant supply of energy.)

In summary, then, here are the major foreign-aid possibilities that tender minds are willing to entertain:

- a. Food plus energy—a conceivable, but practically impossible program.
- b. Food alone—a conceivable and possible program, but one which would destroy the recipient.

In the light of this analysis the question of triage⁸ shrinks to negligible importance. If *any* gift of food to overpopulated countries does more harm than good, it is not necessary to decide which countries get the gift and which do not. For posterity's sake we should never send food to any population that is beyond the realistic carrying capacity of its land. The question of triage does not even arise.

Joseph Fletcher neatly summarized this point when he said, "We should give if it helps but not if it hurts." We would do well to memorize his aphorism, but we must be sure we understand the proper object of the verb, which is the recipient. Students of charity have long recognized that an important motive of the

giver is to help himself, the giver.¹⁶ Hindus give to secure a better life in the next incarnation; Moslems, to achieve a richer paradise at the end of this life; and Christians in a simpler day no doubt hoped to shorten their stay in purgatory by their generosity. Is there anyone who would say that contemporary charity is completely free of the self-serving element?

To deserve the name, charity surely must justify itself primarily, perhaps even solely, by the good it does the recipient, not only in the moment of giving but in the long run. That every act has multiple consequences was recognized by William L. Davison, who grouped the consequences of an act of charity into two value-classes, positive and negative.¹⁷ True charity, he said,

confers benefits, and it refrains from injuring. . . . Hence, charity may sometimes assume an austere and even apparently unsympathetic aspect toward its object. When that object's real good cannot be achieved without inflicting pain and suffering, charity does not shrink from the infliction. . . . Moreover, a sharp distinction must be

drawn between charity and amiability or good nature—the latter of which is a weakness and may be detrimental to true charity, although it may also be turned to account in its service.

To the ecologically-minded student of ethics, most traditional ethics looks like mere amiability, focusing as it does on the manifest misery of the present generation to the neglect of the more subtle but equally real needs of a much larger posterity. It is amiability that feeds the Nepalese in one generation and drowns Bangladeshi in another. It is amiability that, contemplating the wretched multitudes of Indians asks, "How can we let them starve?" implying that we, and only we, have the power to end their suffering. Such an assumption surely springs from hubris.

Fifty years ago India and China were equally miserable, and their future prospects equally bleak. During the past generation we have given India "help" on a massive scale; China, because of political differences between her and us, has received no "help" from us and precious little from anybody else. Yet who is better off today? And whose future prospects look brighter? Even after generously discounting the reports of the first starry-eyed Americans to enter China in recent years, it is apparent that China's 900 million are physically better off than India's 600 million.

All that has come about without an iota of "help" from us.

Could it be that a country that is treated as a responsible agent does better in the long run than one that is treated as an irresponsible parasite which we must "save" repeatedly? Is it not possible that robust responsibility is a virtue among nations as it is among individuals? Can we tolerate a charity that destroys responsibility?

Admittedly, China did not reach her present position of relative prosperity without great suffering, great loss of life. Did millions die? Tens of millions? We don't know. If we had enjoyed cordial relations with the new China during the birth process no doubt we would, out of a rich store of amiability, have seen to it that China remained as irresponsible and miserable as India. Our day-to-day decisions, with their delayed devastation, would have been completely justified by our traditional, posterity-blind ethics which seems incapable of asking the crucial question, "And then what?"

Underlying most ethical thought at present is the assumption that human life is the *summum bonum*. Perhaps it is; but we need to inquire carefully into what we mean by "human life." Do we mean the life of each and every human being now living, all

4,000,000,000 of them? Is each presently existing human being to be kept alive (and breeding) regardless of the consequences for future human beings? So, apparently, say amiable, individualistic, present-oriented, future-blind Western ethicists.

An ecologically-oriented ethicist asks, "And then what?" and insists that the needs of posterity be given a weighting commensurate with those of the present generation. The economic prejudice that leads to a heavy discounting of the future must be balanced by a recognition that the population of posterity vastly exceeds the population of the living.¹⁸ We know from experience that the environment can be irreversibly damaged and the carrying capacity of a land permanently lowered.¹⁴ Even a little lowering multiplied by an almost limitless posterity should weigh heavily in the scales against the needs of those living, once our charity expands beyond the limits of simple amiability.

We can, of course, increase carrying capacity somewhat. But only hubris leads us to think that our ability to do so is without limit. Despite all our technological accomplishments—and they are many—there is a potent germ of truth in the saying of Horace (65–8 B.C.): *Naturam expelles furca, tamen usque recurret*. "Drive nature off with a pitchfork, nevertheless she will return with a rush." This is the message of Rachel Carson,¹⁹ which has been corroborated by many others.²⁰

The morality of an act is a function of the state of the system at the time the act is performed—this is the foundation stone of situationist, ecological ethics.¹² A time-blind absolute ethical principle like that implied by the shibboleth, "the sanctity of life," leads to greater suffering than its situationist, ecological alternative—and ultimately and paradoxically, even to a lesser quantity of life over a sufficiently long period of time. The interests of posterity can be brought into the reckoning of ethics if we abandon the idea of the sanctity of (present) life as an absolute ethical ideal, replacing it with the idea of the sanctity of the carrying capacity.

Those who would like to make the theory of ethics wholly rational must look with suspicion on any statement that includes the word "sanctity." There is a whole class of terms whose principal (and perhaps sole) purpose seems to be to set a stop to inquiry: "self-evident" and "sanctity" are members of this class. I must, therefore, show that "sanctity" is used as something more than a discussion-stopper when it occurs in the phrase "the sanctity of the carrying capacity."

Some there are who so love the world of Nature (that is, Nature *sine* Man) that they regard the preservation of a world without humankind as a legitimate objective of human beings. It is difficult to argue this ideal dispassionately and productively. Let me only say that I am not one of this class of nature-lovers; my view is definitely homocentric. Even so I argue that we would do well to accept "Thou shalt not exceed the carrying capacity of any environment" as a legitimate member of a new Decalogue. When for the sake of momentary gain by human beings the carrying capacity is transgressed, the long-term interests of the same human beings—"same" meaning themselves and their successors in time—are damaged. I should not say that the carrying capacity is something that is *intrinsically* sacred (whatever that may mean) but that the rhetorical device "carrying capacity" is a shorthand way of dealing time and posterity into the game. A mathematician would, I imagine, view "carrying capacity" as an algorithm, a substitute conceptual element with a different grammar from the elements it replaces. Algorithmic substitutions are made to facilitate analysis; when they are well

chosen, they introduce no appreciable errors. I think "carrying capacity" meets significant analytical demands of a posterity-oriented ethics.

In an uncrowded world there may be no ethical need for the ecological concept of the carrying capacity. But ours is a crowded world. We need this concept if we are to minimize human suffering in the long run (and not such a very long run at that). How Western man has pretty well succeeded in locking himself into a suicidal course of action by developing and clinging to a concept of the absolute sanctity of life is a topic that calls for deep inquiry. Lacking the certain knowledge that might come out of such a scholarly investigation, I close this essay with a personal view of the significance of—

CARRYING CAPACITY*

(To Paul Sears)

A man said to the universe:
"Sir, I exist!"
"However," replied the universe,
"The fact has not created in me
A sense of obligation."
—Stephen Crane, 1899.

So spoke the poet, at century's end;
And in those dour days when schools displayed the world,
"Warts and all," to their reluctant learners,
These lines thrust through the layers of wishfulness,
Forming the minds that later found them to be true.

All that is past, now.
Original sin, then mere personal ego,
Open to the shafts of consciousness,
Now flourishes as an ego of the tribe
Whose battle cry (which none dare question) is
"Justice!"—But hear the poet's shade:

A tribe said to the universe,
"Sir, We exist!"
"So I see," said the universe,
"But your multitude creates in me
No feeling of obligation.

"Need creates right, you say? Your need, your right?
Have you forgot we're married?
Humanity and universe—Holy, indissoluble pair!
Nothing you can do escapes my vigilant response.

"Dam my rivers and I'll salt your crops;
Cut my trees and I'll flood your plains.
Kill 'pests' and, by God, you'll get a silent spring!
Go ahead—save every last baby's life!
I'll starve the lot of them later,
When they can savor to the full
The exquisite justice of truth's retribution.
Wrench from my earth those exponential powers
No wobbling Willie should e'er be trusted with:
Do this, and a million masks of envy shall create
A hell of blackmail and tribal wars
From which civilization will never recover.

"Don't speak to me of shortage. My world is vast
And has more than enough—for no more than enough.
There is a shortage of nothing, save will and wisdom;
But there is a longage of people.

"Hubris—that was the Greeks' word for what ails you.
Pride fueled the pyres of tragedy
Which died (some say) with Shakespeare.
O, incredible delusion! That potency should have no limits!
'We believe no evil 'til the evil's done'—
Witness the deserts' march across the earth,
Spawned and nourished by men who whine, 'Abnormal weather.'

Nearly as absurd as crying, 'Abnormal universe!' . . .
But I suppose you'll be saying that, next."

Ravish capacity: reap consequences.

Man claims the first a duty and calls what follows
Tragedy.

Insult—Backlash. Not even the universe can break
This primal link. Who, then, has the power
To put an end to tragedy? Only those who recognize
Hubris in themselves.

*Copyright: Garrett Hardin, 1975.

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The Amateur Electrician's Handbook

*A Book for the Boy or Man Who Wants
to Make and Do Things Electrical*

By

A. FREDERICK COLLINS

Inventor of the Wireless Telephone; Author of "The Radio
Amateur's Handbook," "Wonders of Chemistry," etc.

*Fully Illustrated With Original Drawings and Diagrams
Made Especially for this Book*

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NEW YORK

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3 THE AMATEUR ELECTRICIAN'S HANDBOOK

I

ABOUT FRICTIONAL, OR STATIC ELECTRICITY

THE best and easiest way to learn how electricity acts and how to use it is to (a) start at the beginning of the science and (b) make the experiments described in this book. Now, while there is only one fundamental kind of electricity, it acts differently, depending on whether there is (a) a small or a large quantity of it, or *amperage*, as it is called; and whether (b) it is under a high or a low pressure, or *voltage*, as it is called.

When there is a small quantity of it and it is under a high pressure and at rest, it is called (1) *static electricity*, or *frictional electricity*, if it is generated by friction, but (2) if there is a large quantity of it and it is under a comparatively low pressure and it is flowing in a wire, or other conductor, it is called *current electricity*, or an *electric current*, or just *current* for short.

Static, or frictional electricity is that form of it which was discovered first and with which men worked and experimented until away along to the nineteenth century; but in 1800 current electricity was discovered,

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and this is the form that has resulted in the marvellous uses of it as we know it to-day.

The Discovery of Static, or Frictional Electricity.—We get the word, electricity, and other electrical words from the Greek word *elektron*, and the Latin word *electrum*, both of which mean *amber*, a substance known to the Greeks as early as the Homeric Age. Amber is a hard, brittle and translucent vegetable resin, which usually has a light yellow color. It is easily electrified, and it was the first substance to show the property of electricity.

Now, in the first half of the sixth century before the Christian Era, there lived in Miletus one of the seven wise men of Greece, and he was very wise indeed. His name was Thales, and among the other wonderful things he did, he discovered that when a piece of amber was rubbed it would attract light particles of matter to it, just as a magnet attracts particles of iron. In a word, he had discovered electricity.

Nothing further was found out about electricity or how to generate it for the next two thousand years; then Dr. Gilbert, of Colchester, England, began a series of experiments and learned that not only amber, but jet, glass, sealing wax, sulphur, and other substances would attract bits of paper and other light bodies. These substances which he could electrify he called *electrics*, and since his time the energy which causes electrified bodies to be attracted to and repelled by each other has been called electricity.

How to Generate Static, or Frictional Electricity.—There are several ways by which you can generate enough static, or frictional electricity, so that you can

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observe the effects of it. One of these is to rub a cat; another way is to comb your hair with a rubber comb; a third way is to rub a piece of paper with your finger nails; and a fourth way is to rub a glass rod with a

piece of silk, or a stick of sealing wax with a piece of flannel. In generating electricity by any of these means, everything must be perfectly dry, and this is the reason these experiments succeed so very well in the winter and sometimes not at all in the summer. Even on many hot days, it is humid, that is, the atmosphere is filled with moisture, and this will prevent successful experiments such as the above.

The Electrified Cat.—If the weather is quite dry and you rub an ordinary four-legged cat, you will hear crackling sounds and its hair will be attracted to your fingers. Rub the cat in a dark room and you will see a succession of minute bright sparks. While stroking the cat's back with your right hand, touch the animal's nose with one of the fingers of your left hand, and pussy will think that Jove has hurled a lightning bolt at her.

The Electrified Comb.—Tear up a piece of tissue paper into bits and lay them on the table; then warm a rubber comb slightly to drive away the moisture, and comb your hair with it, when it will soon become electrified; this done, hold the comb within one-eighth inch of the bits of paper, when the latter will be attracted to it.

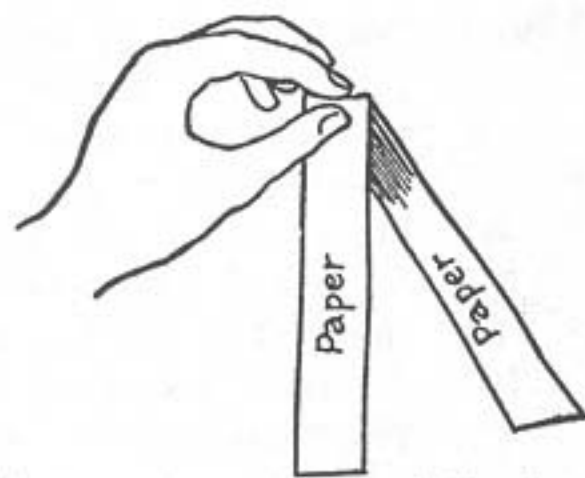
The Electrified Papers.—(*First Experiment.*) Tear a sheet of newspaper into strips, so that they will be about three inches wide and a foot long, and dry them out thoroughly. Hold one of the strips by

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one end on your leg, as shown at A in Fig. 1, and rub the paper with the finger nails (because these are perfectly dry) of your right hand. To do this with-



A. How to Electrify the Papers.



B. The Effect of Electric Repulsion.

Fig. 1. The Electrified Papers.

out crumpling the paper and losing time, move your hand that is making the rubbing strokes quickly and firmly down and away from your fingers which hold the paper.

After half a dozen strokes or so, grip the top end of the paper and you will find that it clings as tightly to your trouser leg as a porous plaster to a hairy back. Moreover, it will stick to your hand, the wall, or any other object, provided of course the latter is perfectly dry. This effect is called electric attraction, and a funny modification of it is given in Chapter XI on "Electrical Toys and Tricks."

(*Second Experiment.*)—Hold two strips of newspaper on your leg, as above described and pictured,

7 electrify both of them, and then hold their ends together, as shown at *B*, when instantly the free ends will repel each other. This effect is due to electric repulsion, and I shall explain about it farther on. Now place your open hand between the two strips of paper and they will be attracted to it. There are many similar, interesting experiments which may be performed in the same way.

The Pith Ball Pendulum.—Take a piece of stiff wire about eight inches long, and bend over one end, as shown at *A* in *Fig. 2*. Then fasten the other end

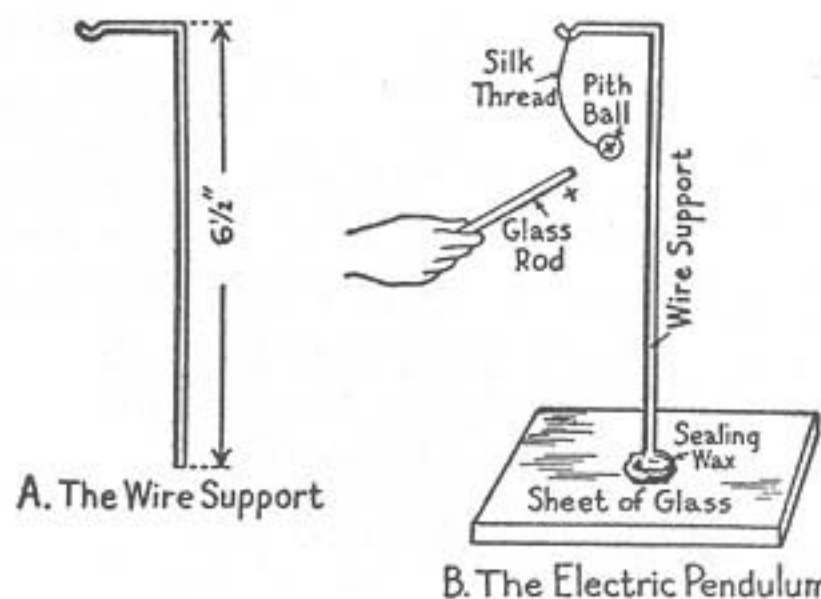


Fig. 2. How the Electric Pendulum is Made and Used.

to a sheet of glass with sealing wax; next, suspend a pith ball¹ by means of a fine silk thread from the free 8 or bent end of the wire, and then rub a glass rod with a piece of perfectly dry silk, when it will be "positively" electrified.

¹Pith is the soft, spongy tissue found in the center of the stems and branches of certain plants.

Hold the end of the rod close to the pith ball, when the latter will be attracted to it and then repelled by it, as shown at *B*.

What Electric Attraction and Repulsion Is.—

From the above experiments, it is easy to believe that there are two kinds of electricity, and, indeed, these two forms of it are called *positive* and *negative* electricity, but they are simply both parts of the same charge, for whenever you have a positive charge there in the immediate neighborhood you will have an equal negative charge, and the other way about.

As an illustration, just as a druggist's scale has a balanced beam, so an electric charge is balanced energy. As long as the beam of the scale remains balanced, it is at rest, but the moment one side or the other is weighted a little the beam begins to move one way or the other. Just so with an electric charge, for as long as the positive and negative charges of which it is formed remain equal, the electricity is at rest, but the moment you add to or take away from either the positive or negative charges, it begins to act and there is a strain set up in the air space or material between them.

What Electro-Static Induction Means.—When one electrified body acts on and electrifies another body without their being in actual contact with each other, the transfer of electric energy is said to be produced by *electro-static induction*, or just *induction*, as it is called. Thus, when you rub a glass rod, you give it a 9 positive charge and the air surrounding it will have an equal negative charge.

Now, when you hold one end of the positively charged rod close to the suspended pith ball, as shown in *Fig. 2*, the latter is charged with negative electricity by induction, and, hence, this is what we call an *induced* charge. The way the positive charged and negative charged bodies are connected by electric lines of force is shown in *Fig. 3*.

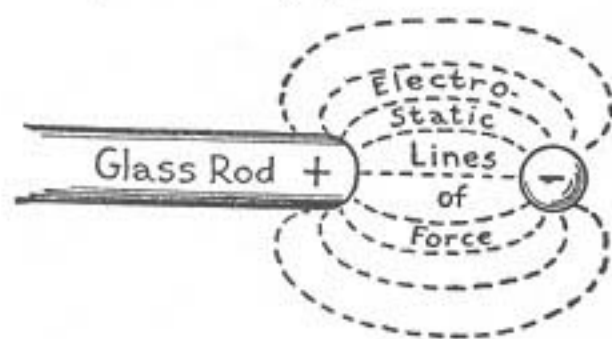


Fig. 3. Electro-Static Lines of Force.

Always remember that like charges of electricity repel each other, and that unlike charges attract each other; that is to say, a positive charge will repel a positive charge, and a negative charge will repel a negative charge, while a positive charge will always attract a negative charge, and the other way about.

Further, when you electrify a strip of paper by rubbing it on your leg or on a table, the paper takes on a positive charge, while your trousers take on a negative charge. Now, you may wonder how this can be so when they are in contact with each other; as a matter of fact, they make actual contact only at a very small number of points, and the air between them still acts as an insulator.

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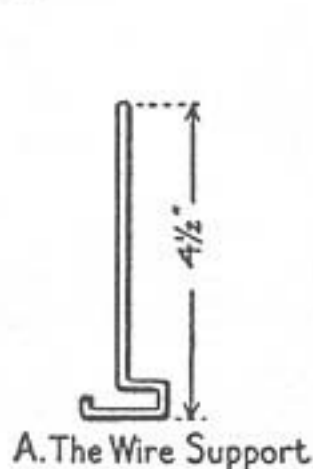
What an Electroscope Is.—The word electroscope comes from the Greek words which mean amber (representing electricity) and "to see"; in other words, it means "to see electricity," and while, of course, you cannot really see electricity, you can see the effects of it. The electroscope is made on the principle of the experiment with the strips of paper, which when both are electrified, either positively, or negatively, they fly apart. In the electroscope, however, little strips of gold leaf are used, and since only a very small amount of electricity is needed to charge them, the instrument is exceedingly sensitive.

The electroscope is largely used at the present time to find out (a) if various substances are *radio-active*, that is, if they give off radium rays, (b) if they do so, to what extent, and (c) if a given substance has an electric charge upon it or is electrified. The leaves are given a charge by holding an electrified glass rod, or other body, near the projecting wire of the electroscope, when they (the leaves) will repel each other. Then the substance to be tested for radio-activity is placed in an opening in the bottom of the electroscope close to the leaves. If now the substance is radio-active, the rays will make the air between and surrounding the leaves a conductor of electricity, and, hence, the charge on the leaves is conducted away by the air and the leaves collapse.

How to Make a Gold Leaf Electroscope.—You can buy a simple electroscope for about seventy-five cents, or you can make one for a few cents and have the fun and satisfaction of doing it all yourself. To make one, get a wide-mouthed bottle about two inches

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in diameter and two and a half inches high. Next, round off both ends of a piece of wire about one-eighth inch in diameter, and four and a half inches long (this is to help keep the electric charge from leaking away), and bend one end into the shape shown at A in Fig. 4; now make a hole in a cork that fits tightly into the neck of the bottle and push the wire about half-way through it. This done, get a strip of gold



A. The Wire Support



B. The Electroscope Complete

Fig. 4. Gold Leaf Electroscope.

leaf about three-eighths of an inch wide and two inches long from a sign-painter; bend it over, and then lay it across the arm of the wire; finally, push the cork in the bottle and your electroscope is done, as shown at B.

If you want to find out whether a body is electrified or not, all you have to do is to hold it close to the exposed end of the wire of the electroscope; if it is either positively or negatively electrified, the leaves will repel each other, for like *signs*, or charges, of elec-

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tricity repel each other. Should you want to dissipate the charge on the gold leaves, all you have to do is to touch the exposed end of the wire with your finger, or to a wire connected to a water or gas pipe, when the charge will be conducted through your body to the earth.

What an Electrophorus Is.—We get the word electrophorus (pronounced *e-lek-trof'-o-rus*) from the Greek words *elektron* and *phero*, which means "to bear," that is, it bears electricity, hence it is an apparatus that generates electricity by friction and induction.

It was the first piece of apparatus made that would generate and store up more electricity than could be done by rubbing a glass rod or a stick of sealing wax. The Italian physicist, Volta, got it up just about the time that our Liberty Bell was ringing out the independence of the United States, and it is still in use in schools for the production of small amounts of static electricity.

How to Make a Cheap Electrophorus.—An electrophorus consists of a hollowed out metal disk filled with a resinous composition, called the plate, or sole, and a metal disk fitted with an insulated handle, called the cover, which rests on the plate. Now, you

can buy a well-made electrophorus, such as is used in the physics classes of high schools, for about three dollars, or you can make one for half a dollar, or less.

To make one, get two new, small pie-pans, and into one pour enough mixture, made by melting eight ounces of brown resin and six ounces of gum shellac and stirring them together thoroughly, to fill it;

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then fasten the end of a stick of sealing wax to the center of the inside of the other pan for a handle, when your electrophorus is complete, as shown in Fig. 5.

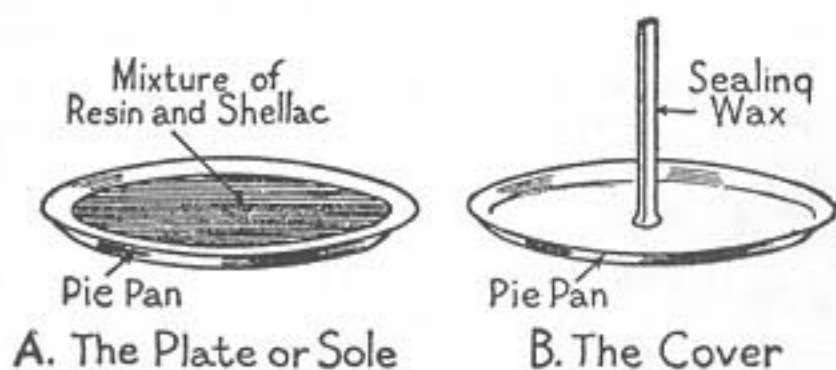


Fig. 5. The Electrophorus Complete.

How to Generate Electricity with Your Electrophorus.—To generate a charge with your electrophorus, all you have to do is to set the cover to one side and then rub the surface of the plate with a warm piece of flannel, when it will be charged with negative electricity. Now set the cover back on the plate, but be careful the edge of it does not touch the edge of the other pie-pan.

As the surface of the mixture in the pan is very uneven, there is a thin layer of air between it and the cover and, hence, they make contact at a very few points, and, consequently, the bottom of the cover is charged by induction with positive electricity, while the top of it is charged with negative electricity, as shown at A in Fig. 6. To get the full effect of the positive charge, you must get rid of the negative charge on the cover, and this you do by simply touching it with your finger, as shown at B.

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When you lift the cover by the insulating handle, the positive charge, which was kept to the lower surface by the negative charge of the plate, is distributed all over the cover; now, by lifting the cover and holding the knuckle of a finger of your other hand close to it, as shown at C, you will get a spark. Having done this, you set the cover back on the plate again, touch it with your finger, take it off, and you can get another spark from it that is almost as intense as the

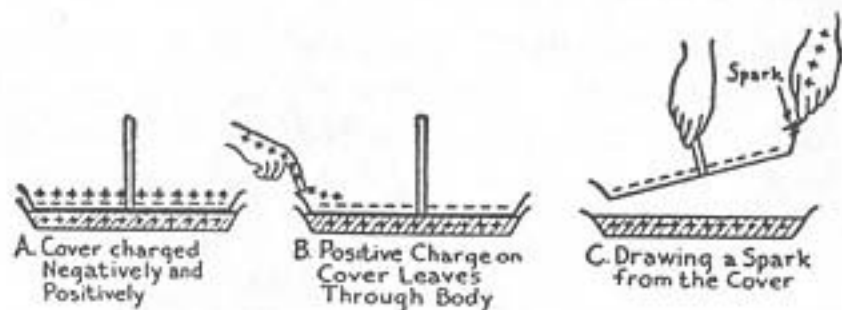


Fig. 6. Cross Section of the Electrophorus Showing How it Acts. first.

What a Leyden Jar Is.—The electrophorus, which I have just described, acts as an *electric condenser* in that it stores up electricity, as well as being a generator of electricity. However, the Leyden jar is the most familiar form of electric condenser, and it is the oldest, having been discovered by Von Kleist, of Kammin in 1745 and by Cunnæus and Musschenbroek of Leyden, Holland.

Van Kleist took a bottle, in the neck of which was a large nail, and this he held close to one pole of his frictional electric machine; removing the bottle from the machine, he was surprised when on touching

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the nail he got a shock. But it was Sir William Watson, of England, who conceived the idea of coating the inside and outside of a bottle with tinfoil, and when he charged this with his electrical machine he received a powerful shock for his pains. In this way, then, that kind of a condenser which we call the Leyden jar came into being.

How to Make a Glass Condenser.—There are three different ways that you can make a glass condenser, and these are (1) by using a sheet of glass and fixing a sheet of tinfoil on both sides of it; (2) by coating a tumbler on the inside and outside with tinfoil, and, finally, (3) by coating a large wide-mouthed bottle, or glass jar, inside and outside, with tinfoil, and (4) by using alternate layers of glass plates and foil.

A Glass Plate Condenser.—Get a sheet of clear glass eight by ten inches on the sides, and give it a coat of shellac varnish all over and let it dry; then give it another coat of varnish and before it is dry lay a sheet of tinfoil six by eight inches on the sides on each side of it, as shown at A in Fig. 7, and rub them down smooth so that there will be no air bubbles between them and the glass when the varnish is dry.

A Glass Tumbler Condenser.—This is an easy condenser to make, and it is much more convenient to handle than the glass plate condenser just described. Get a large tumbler and coat it all over with shellac

varnish, as described in connection with the glass plate condenser above. Then coat it inside and out with tinfoil to within about an inch of the top, as shown at *B*.

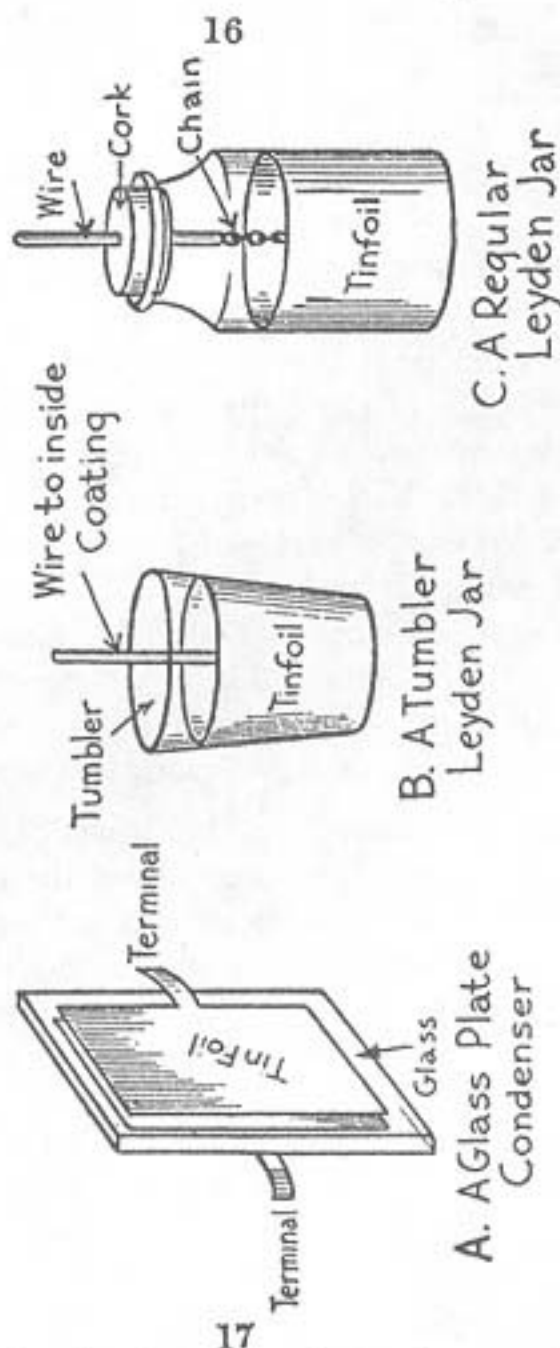


Fig. 7. Three Kinds of Glass Condensers.

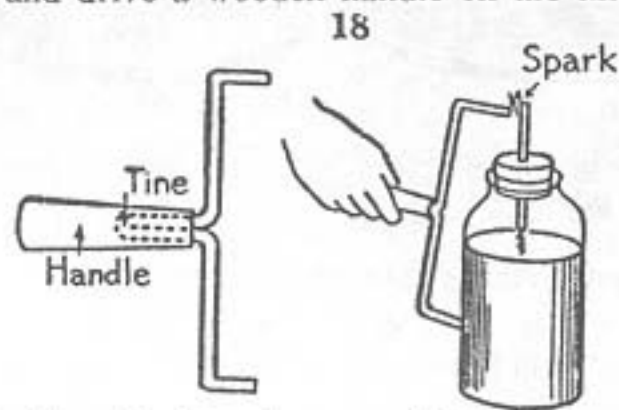
A Leyden Jar Condenser.—A glass jar condenser is the best kind for experimental work, but it is not as easy to make as the other two kinds I have described. To make one, get a bottle, or a jar, that is large enough to slip your hand into—and out of—when you want to. Shellac it and then coat it with tinfoil inside and out, as explained above.

This done, get a piece of wire or a rod about one-eighth inch thick and four inches long, and round off the ends; then solder a piece of small brass chain to one end and push the other end through a cork, which you have previously shellaced, and put this into the neck of the bottle or the jar. The chain will make contact with the inside coating of the jar, and to discharge it you need only to touch one end of a wire to the outside coating and bring the other end of it close

to the rod. A Leyden jar thus made is shown at *C*.

How to Charge a Leyden Jar.—To charge a Leyden jar, hold it in your hand, or place it on a table and run a wire from the outside coating to the earth; now hold the exposed end of the rod that connects with the inside coating to either the cover of a charged electrophorus, or better, one of the poles of a frictional, or a static electric machine.

How to Make a Leyden Jar Discharger.—A charged glass plate condenser or a Leyden jar will give such a powerful discharge that it is necessary to use a *discharger* of some kind to keep from getting a shock. To make one, get a piece of brass wire about one-eighth inch thick and eleven inches long, and round off the ends of it; then bend it, as shown at *A* in Fig. 8, and drive a wooden handle on the tine formed by



A. How the Discharger is made B. How the Discharger is used

Fig. 8. How the Leyden Jar is Discharged.

the wire where it is bent over on itself. The way the Leyden jar is discharged is shown at *B*.

The Frictional Electric Machine.—It is quite natural that the first machines made to generate static electricity were those in which a glass globe, cylinder or disk, was mounted so that it could be rotated while a rubber made of silk pressed against it. It took a good deal of power to run these frictional machines, as they are called, and because of this and the advent of the induction machine, which is based on the principle of the electrophorus, they are seldom used any more.

ADDENDA

The Wimhurst Influence machine was not described in the 1924 book, but was, instead, advertised for sale by an electronics firm.

Harper's Electricity For Boys, 1907, was not as extensive as The Amateur Electrician's Handbook, 1924, but it did have the Wimhurst.

I also added two chapters from the 1907 book which had formulas and miscellaneous apparatus not in the 1924 book. These sections are at the end of *The Amateur Electrician's Handbook*.

ELECTRICITY BOOK FOR BOYS

FRictional Electricity

FRICTIONAL electricity is high potential, current alternating, and of high voltage but very low ampérage. Apart from certain uses in laboratory and medical practice, it is valueless. In its greater volume it is akin to the lightning-bolt and is dangerous; but in its smaller volume it is a comparatively harmless toy. From the glass rod, or the amber, rubbed on a catskin to the modern static machines is a long jump, and the period of exploitation covers centuries of interesting experiments, most of which, however, have been practically useless for any commercial purpose.

Static or frictional electricity is generated by friction only, without the aid of magnets, coils of wire, or armatures rotating at high speed. The simple process of the glass and catskin has been variously modified, until at last Wimshurst invented and perfected what is known as the "Wimshurst Influence Machine." It is self-charging, and does not require "starting." It will work all the year round in any climate and temperature, and is the greatest improvement ever made in static electric machines.

Apart from its efficiency under all conditions, it is the simplest of all machines to make, and can easily be constructed by a boy who is handy with tools, and who can obtain the glass and brass parts necessary in its construction. The principal parts of an influence machine are the glass disks, wooden bosses, driving pulleys and crank, glass standards, brass arms with the spark-balls at the ends, and the base with the uprights on which these parts are built up and held in position.

A Wimshurst Influence Machine

Obtain a stiff piece of brown paper twenty inches square, and with a compass describe a circle twenty inches in diameter. Inside of this circle make another one fourteen inches in diameter, and near the centre a third circle six inches in diameter. Another circle four inches in diameter should be drawn inside of the six-inch circle, so that when the bosses are made fast to the glass plates they can be properly centred. Also mark sixteen lines radiating from the centre, equal distances apart, as shown in Fig. 1.

From a dealer in glass purchase two clear, white panes of glass eighteen inches square. Be careful not to get the green glass, as this is not nearly so good as the white for static machine construction. If it is possible to get crystal plate so much the better. The panes should be thin, or about one-sixteenth of an inch in thickness, and free from

bubbles, wavy places, scratches, or other blemishes.

From these panes cut two disks sixteen inches in diameter with a rotary cutter, as described in the chapter on Miscellaneous Apparatus, page 294, and rub the edges with a water-stone (see chapter on Formulæ, page 330.)

From flat, thin tin-foil cut thirty-two wedge-shaped pieces four inches long. They should be one inch and a half wide at one end and three-quarters of an inch at the other, as shown at Fig. 2 A. Give each plate of glass two thin coats of shellac on both sides; then lay one on the paper pattern (Fig. 1) so that the outside edge of the glass will lie on the largest circle. Place a weight at the middle of the glass to hold it in place; then make sixteen of the tin-foil sectors fast to the plate, using shellac as the sticking medium. But first give one side of each sector a thin coat of shellac, allowing it to dry; then give it another coat when applying it to the glass. The sectors are to be symmetrically arranged on the glass, using a line of the pattern as a centre for each piece (as shown at A in Fig. 1), and the fourteen and six inch circles as the outer and inner boundaries. Each piece, as it is applied, should be pressed down upon the glass, so that it will stick smoothly, without air bubbles or creases. A very good plan is to lay a piece of soft blotting-paper over the sector and drive it down with a small squeegee-roller such as is used in photography, taking care, however, not to shift the sector from its proper position. When all the sectors are on, the plate should appear as shown in Fig. 2. After the shellac, which holds the

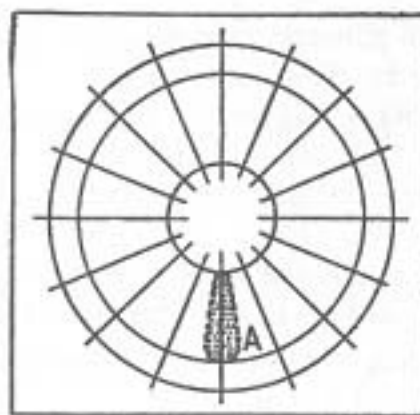


FIG. 1.

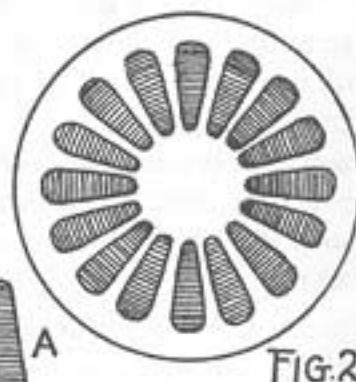


FIG. 2.



FIG. 3.



FIG. 4.

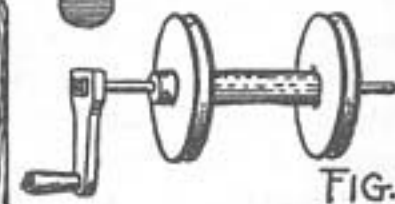


FIG. 5.

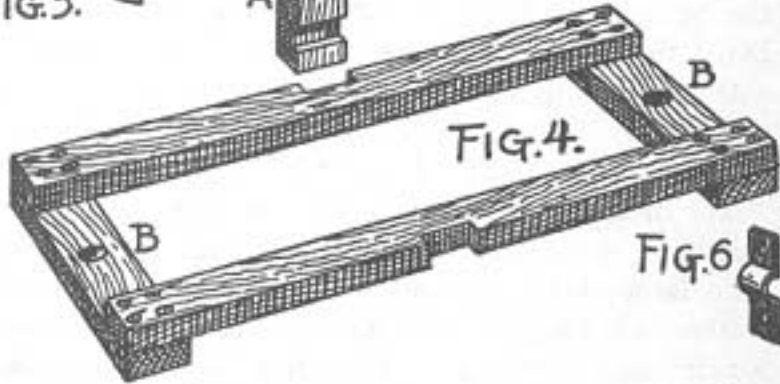


FIG. 6.

sectors to the glass, is dry, run a brush full of shellac around the inner and outer extremities of the tin-foil strips for half or three-quarters of an inch in from the ends. The shellac will hold the sectors firmly to the glass, and will slightly insulate them as well, thereby preventing the escape of electricity. Apply the remaining sectors to the other plate of glass in a similar manner; and as a result two disks of glass, with the applied strips, will be ready to mount in the frame.

A hole three-quarters of an inch in diameter should be made in each glass plate, so that a three-eighths spindle may pass through them and into the bosses, so as to keep them in proper line. It is preferable, however, not to bore these holes if bosses and accurately bushed holes can be made in the uprights of the frame which support these disks.

At a wood-working mill have two bosses made that will measure four inches in diameter at the large end, and one inch and a half at the small one. They should be of such length that when the plates and two bosses are arranged in line (to appear as shown in A A at Fig. 9) they will fill the entire space between the uprights B B. Near the small end a groove is turned in each boss, so that a round leather belt will fit in it, as shown in Fig. 3.

The base is made from pine, white-wood, cypress, or any other wood that is soft and easily worked. It is composed of two strips twenty-four inches long, three inches wide, and one inch and a quarter in thickness, and two cross-pieces fourteen inches long, three inches wide, and one inch and a half thick.

These are put together with glue and screws, and at both sides of the base notches are cut to accommodate the feet of the uprights. The uprights are seventeen inches high, three inches wide, and one inch and a half thick. The notch at the foot of each one is cut so that, when fitted in place, the foot of the upright will rest on a table on a line with the bottom of the end cross-pieces under each corner. At the foot of the uprights a piece of sheet rubber should be made fast, with glue or shellac, so that when in operation the machine will not move about or slide.

A groove is cut at one side of each upright six inches above the bottom, as shown at Fig. 4 A. In this groove the driving-wheel axles fit, and near the top holes are made in the uprights through which the spindles pass, which in turn support the bosses and glass disks.

At the middle of each cross-piece forming the ends of the base a one-inch hole, for the glass standard rods, is bored through the wood, as shown at Fig. 4 B B. After attaching the uprights to the base with glue and screws, and giving all the wood-work several successive coats of shellac, the frame will be ready for its mountings.

The driving-wheels are of wood seven-eighths of an inch thick and seven inches in diameter; they should be turned on a lathe and a groove cut in the edge so that a round leather belt will fit in it. These wheels are mounted on a wooden axle that can be made from a round curtain-pole, with a half-inch hole bored through its entire length. The

axle is as long as the distance between uprights B B in Fig. 9. The wheels are to be arranged and glued fast to the axle, so that the grooves will line directly under those in the bosses, as shown in Fig. 9. A half-inch axle is driven through the hub, and at one end it is threaded and provided with two washers and nuts; or a square shoulder and one washer and nut may be used, so that a crank and handle may be held fast. Shellac should be put on the shaft to make it hold fast in the hub.

The complete apparatus of wheels, axle, hub, and handle is shown at Fig. 5, and in the frame this is so hung that the iron axle rests in the grooves cut in the uprights. To hold this in place two metal straps, as shown in Fig. 6, are made and screwed fast to the wood. When finally adjusted the driving-wheels should rotate freely whenever the crank is turned. The wooden bosses, Fig. 3, are given two or three coats of shellac; then they are made fast to the glass disks on the same side to which the tin-foil sectors are attached. The disks should be placed over the paper plan, Fig. 1, and so adjusted that the outer line tallies with the large circle. Acetic glue¹ is then applied to the flat surface of the boss, and the latter is placed at the middle of the disk to line with the small circle. Place a weight on the end of the boss to hold it down, and leave it for ten or twelve hours or until thoroughly dry.

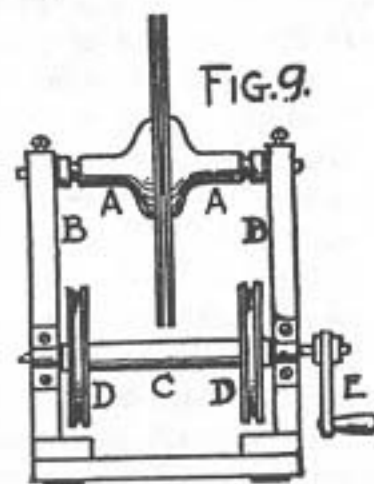
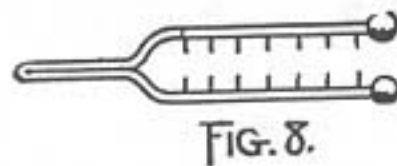
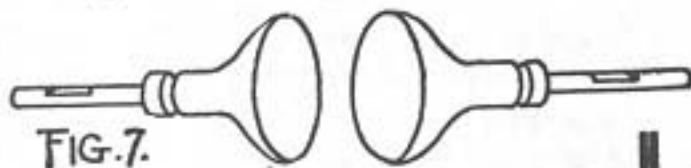
¹See Formulae,

for the recipe of acetic glue.

Both bosses should be set at the same time so that they may dry together.

If the bosses are turned on a lathe a hole should be made in each one about half-way through from the small end. This, in turn, should be bushed or lined with a piece of brass tube, which should fit snugly in the hole. A little shellac painted on each piece of tube will make it stick. Pieces of steel rod that will just fit within the tubing are to be cut long enough to enter the full length of the hole, pass through the holes made in the top of the uprights, and extend half an inch beyond, as shown in Fig. 9. The bosses and axles will then appear as shown in Fig. 7.

Flat places should be filed on each rod where it passes through the wood upright; a set-screw will then hold it



fast and keep it from revolving. When the hole, or tubing, is oiled so that the boss and disk will revolve freely on the axle, the disks, bosses, and axles are ready to be mounted in the frame.

A red fibre washer, such as is used in faucets, should be made fast to one glass disk at the centre, so as to separate the disks and prevent them from touching when they are revolving in opposite directions. These fibre washers can be had from a plumber or purchased at a hardware store. Shellac or acetic glue will hold the washers in place.

Mount one disk by holding the boss with the small end opposite a hole in one upright, and slip an axle through from the outside of the upright. Hold the other disk in place, and slip the remaining axle through the other upright and into the boss. When both plates are in place and centred, turn the set-screws down on the flattened axles to hold them in place.

To reduce the friction between the bosses and the uprights it would be well to place a fibre washer between them. A few drops of oil on these washers will lubricate them properly, and allow the machine to run easier. An end view of the apparatus, as so far assembled, will appear as shown in Fig. 9, A being the disks, bosses, and axles, B B the uprights supporting them, C the hub, and D D the driving-wheels. The handle and crank (E) extends out far enough from the side to allow a free swinging motion without hitting the upright or base. Having arranged these disks and wheels so as to revolve freely, it will now be necessary to construct and add the other vital parts and the connecting links in the chain of the complete working mechanism.

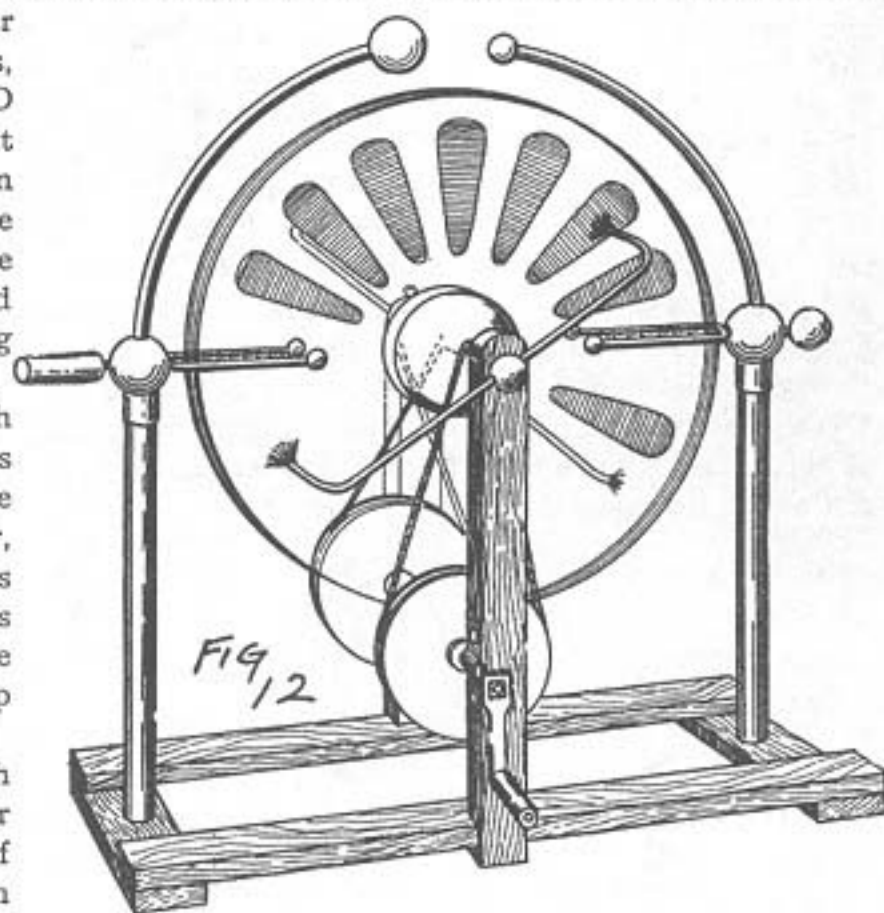
From a supply-house obtain two solid glass rods an inch in diameter and fifteen inches long. These fit in the holes (B B) bored in the end-pieces of the base, Fig. 4. Procure two brass balls, two or two and a half inches in diameter, such as come on brass beds, and two short pieces of brass tubing one inch inside diameter, that will fit over the ends of the rods. These tubings are to be soldered fast to the balls so that both tubes and balls will remain at the top of the glass rods.

From brass rod three-sixteenths or a quarter of an inch in diameter make two forks, as shown at Fig. 8, and solder small brass balls at the ends of the rods. The prongs of the fork are six inches long and the shank four inches in length. Along the inside of the forks small holes are bored, and brass wires, or "points," are soldered fast. These extend out for half an inch from the rods, and are known as the "comb," or collectors. The forks should be so far apart that when mounted with the glass disks revolving between them the points will not touch or scratch the tin-foil sectors, and yet be as close to them as possible. A hole should be bored in the brass balls, and the shank of the fork passed through and soldered in place, as shown in Fig. 10.

A three-eighth-inch hole is bored directly in the top of each brass ball to hold the quadrant rods, which extend over the top of the disks.

In the illustration of the complete machine (Fig. 12) the arrangement of the glass pillars, balls, combs, and quadrant rods is shown. The rods are three-eighths of an inch in diameter and are loose in the holes at the top of the balls, so that they can be moved or shifted about, according as to whether it is a left or a right handed person who may be turning the crank.

At the upper end of each rod a brass ball is soldered, one being three-quarters of an inch in diameter, the other two inches. The projecting ends of the forks should be provided with metal handles or brass balls, as shown in Fig. 12; these may be slipped over the end or soldered fast. Obtain two small brass balls with shanks, such as screw on iron bed-posts, and have the extending ends of the axles that support the bosses threaded, so that the balls will screw on them. Bore a quarter-inch hole through each ball, and slip a brass rod through it and solder it fast. Each end of these rods should be tipped with a bunch of tinsel or fine copper wires. These are the "neutralizers," and the ends are curved so that the brushes of fine wires will just touch the disks when the latter are revolved, as shown in Fig. 12.



The ball holding the rod is to be screwed fast to the axle; then the axle is pushed back into the boss and made fast in the head of the upright with the set-screw.

The rod-and-ball at the opposite side of the disks is arranged in a similar manner, but the rod points in an opposite direction to that on the first side. Cord or leather belts connect the driving-pulleys and bosses, the belt on one side running up straight over the boss and down again around the driving-pulley. The belt at the opposite side is crossed, so that the direction of the boss is reversed; and in this manner the disks are made to revolve in opposite

directions, although the driving-pulleys are both going in the same direction.

A portion of the sectors are omitted in the illustration (Fig. 12) so that a better view of the working parts may be had. When the disks are revolving the accumulated electricity discharges from one ball to the other, above the plates, in the form of bright blue sparks sufficiently powerful to puncture cardboard if it is held midway between the balls.

A Large Leyden-jar

When experimenting with this machine it would be well to have one or more Leyden-jars to accumulate static charges. A large one of considerable capacity is easily made from a battery jar, tin-foil, brass rods and chain, and some other small parts.

Obtain a bluestone battery jar, and after heating it to drive all moisture from the surface, give it a coat of shellac inside and out. With tin-foil, set with shellac, cover the bottom and inside of the jar for two-thirds of its height from the bottom, as shown in Fig. 11. Cover the outside and bottom in a similar manner, and the same height from the bottom, and provide a cork, or wooden cap, for the top. If a large, flat cork cannot be had, then make a stopper by cutting two circular pieces of wood, each half an inch thick, the inner one to fit snugly within the jar, the other to lap over the edges a quarter of an inch all around. Fasten these pieces together with glue, as shown at Fig. 13, and give them several good coats of shellac. Make a small hole at the middle of this cap and pass a quarter-inch rod through it, leaving six inches above and below the cap. To the top of the rod solder a brass ball. At the foot a piece of brass chain is to be made fast, so that several links of it rest on the tin-foil at the bottom of the jar.



FIG. 11.



FIG. 13

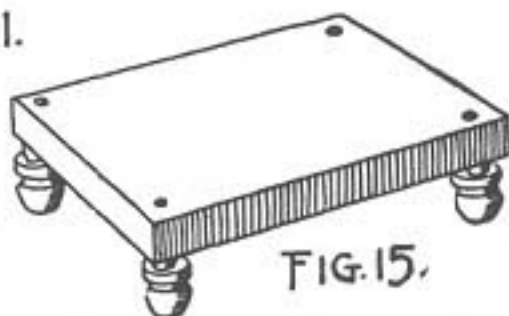


FIG. 15.



FIG. 14.



FIG. 16.

To charge a jar from the Wimshurst machine, stand the jar on a glass-legged stool, and connect a copper wire between one of the overhead balls on the machine and the ball at the top of the rod in the stopper of the jar. Make another wire fast to the other ball at the top of the machine, and place it under the jar so that the tin-foil on the bottom touches it. By operating the machine the jar is charged.

To discharge the jar make a T-yoke, as shown at Fig. 14, by nailing a brass rod fast to a wooden handle and soldering brass knobs, or hammering a lead bullet, on the ends of the rod. Hold one knob against the top knob of the jar and bring the other near the foil coating at the outside, when a spark will jump from the foil to the knob with a loud snap.

A Glass-legged Stool

One of the most useful accessories in playing with frictional electricity will be a glass-legged stool. A stool with glass feet is perhaps too expensive for a boy to purchase, but one may be made at little or no cost from a piece of stout plank, four glass telegraph line-insulators, and the wooden screw-pins on which they rest when attached to a pole.

(Since the object is to separate yourself from the floor with glass, simply get four glass bottles, break them all the way down to their bottoms and glue the bottoms to the bottom of the piece of board you mean to stand on).

The general plan of the stool is shown at Fig. 15, and the top measures twelve by fifteen by two inches. Under each corner a screw-pin is made fast by boring a hole in the wood and setting the pin in glue. The pins are cut at the top, as shown in Fig. 16, and when they are set in place the glass insulators may be screwed on. The wood-work should be given a few coats of shellac to lend it a good appearance and help to insulate it.

There are a great many interesting experiments that may be performed with static or frictional electricity, and these may be looked up in the text-books on electricity used in school. A word of caution will not be misplaced. Remember that the current, in large volume, is dangerous. For example, a series of charged Leyden-jars may contain enough electricity to give a very severe shock to the nervous system of the person who chances to discharge it. Its medical use should be under the advice and supervision of a physician.

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II

EXPERIMENTS WITH A STATIC MACHINE

If you have a static machine of any kind or size, you can perform a large number of interesting and spectacular experiments. You can easily make nearly

all of the apparatus required by using sheets of glass for flat insulating surfaces and sticks of sealing wax for the insulating standards; and bits of paper, sealing wax, corks, pins and needles for the other parts.

The Lightning Conductor.—This experiment shows how a lightning conductor protects property. Put a little ether or benzine in the metal bowl, which is insulated from the spark point, as shown at *A* in *Fig. 11*. Now make the spark from the positive knob

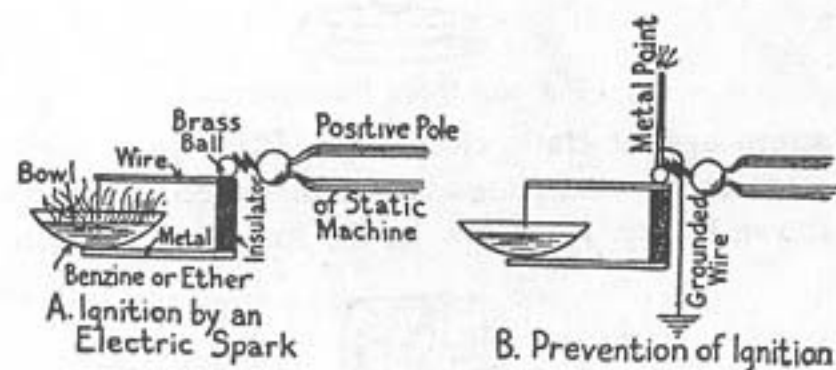


Fig. 11. The Lightning Conductor.

of your electrical machine strike the wire, when the inflammable liquid will be ignited. Next, fasten a pointed wire to the first one, as shown at *B*, and

ground it with a chain; now repeat the experiment, when instead of the spark igniting the liquid, the energy of it will be slowly discharged from the point and into the ground.

The Electrified Sand.—Hook a small funnel on the end of a bent wire and connect this to the positive pole of your electric machine, as shown in *Fig. 12*.

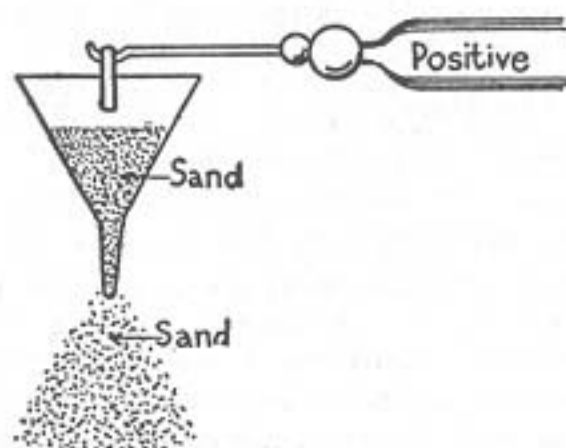


Fig. 12. The Electrified Sand.

This done, fill the funnel with dry, fine sand, when it will run out of the small end in a stream. Now set your electric machine into action by turning the handle of it, when the funnel and its contents will be electrified. As the grains of sand are positively electrified, they will repel each other and fall like so many drops of rain.

The Electric Mortar.—This device consists of a

small metal tube closed at one end and to which is fixed a wire, so that it can be connected with one of the poles of the electric machine. A hole is drilled in one side of it and another wire is set into but insulated from the tube, and this is connected with the

other pole of your machine, as shown in *Fig. 13*. Now when you turn the crank a spark will jump across the inside of the mortar, and this will cause the air to suddenly expand, and a ball that you have placed on

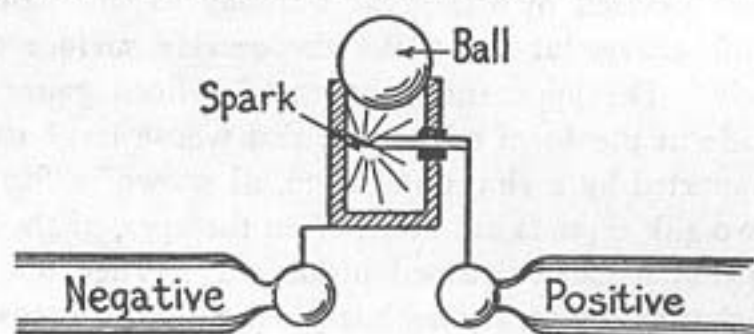


Fig. 13. The Electric Mortar.

the open end of the tube will be shot upward. If you will connect a Leyden jar in the circuit, there will be an explosion of the air, a loud report, and the ball will be projected to a considerable distance.

The Outside Static Charge.—There are a number of experiments that you can make which show that a static charge always finds its way to the outside surface of a body and remains there. The following four experiments demonstrate this phenomenon in a vivid manner.

The Beetz Electroscope.—This is a simple and easily made device and one which shows visually that the charge is on the outside surface. It consists of a

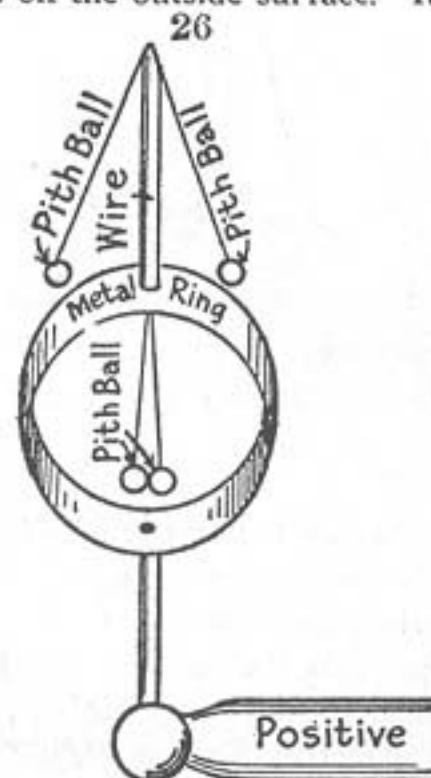


Fig. 14. The Beetz Electroscope.

brass ring about two inches in diameter, in which a pair of pith balls are suspended by silk threads, and outside of which another pair of pith balls are likewise suspended, as shown in *Fig. 14*. Connect the electroscope to one of the poles of your electric machine, or otherwise charge it, when the pair of balls at the top will fly apart and the pair inside the ring will remain stationary.

Faraday's Conical Bag.—This is a famous experiment devised by the great Faraday to show that a static charge always seeks the outside surface of a body. The apparatus consists of a linen gauze bag made in the form of a cone, and whose large end is supported by a ring on a stand, as shown in *Fig. 15*. Two silk threads are attached to the apex of the bag, so that it can be turned inside out. When this bag is charged by an electric machine, and an electroscope is held inside and outside of it, the latter will show that the charge is on the outside surface. Now turn the bag inside out and test it again with your electroscope, when you will find that the charge is still on the outside of it.

Biot's Hemispheres.—This apparatus consists of two polished brass hemispheres with an insulating han-

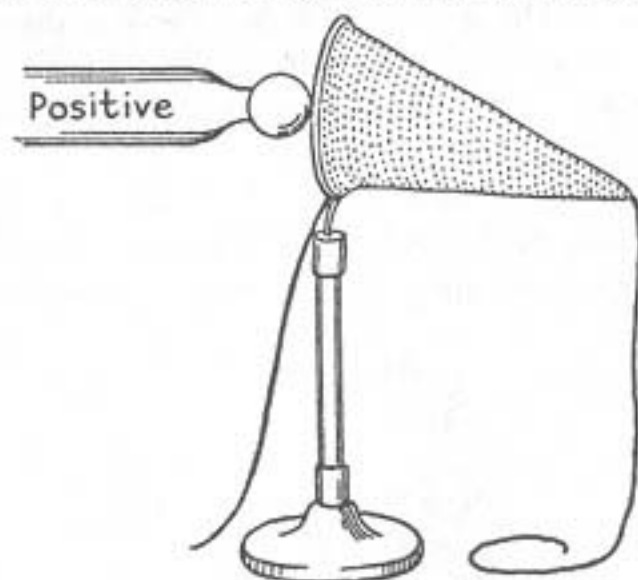


Fig. 15. Faraday's Gauze Bag.

dle fixed to each one; these are made to fit over a brass ball, which is mounted on an insulating support, as shown in *Fig. 16*. Now connect the globe to one of

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the poles of your electric machine and charge it; this done, place the two hemispheres over it and then remove them, when you will find, by testing them with an electroscope, that the ball has lost its charge and that the hemispheres have acquired it.

Faraday's Electric Screen.—This is simply a cylindrical shield made of wire netting that acts as a

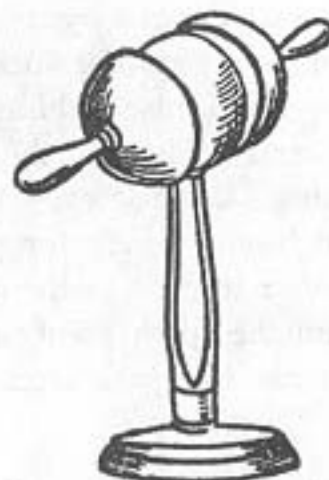


Fig. 16. Biot's Hemispheres.

screen against static electricity. Place your electroscope on a metal plate and set the screen over it, as shown in *Fig. 17*. Now let the sparks of an electric



Fig. 17. Faraday's Electric Screen.

machine strike the wire screen and you will find that the leaves of the electroscope are not affected; but if you will remove the screen, you will find that by holding an electrified glass rod near the electroscope, the leaves will fly apart.

His Hair Standing on End.—For this experiment you need a stool that will perfectly insulate the person, whose hair you are going to raise, from the earth. You can make an insulated stool easily enough by fixing four glazed porcelain insulators to the corners

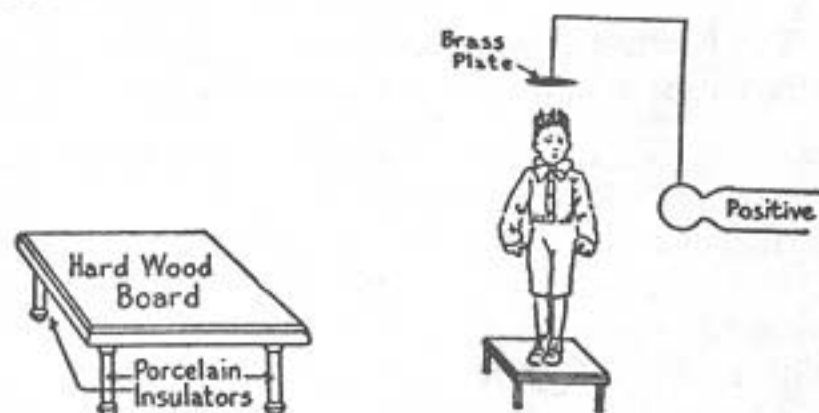
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of a hardwood board one inch thick and thirteen inches on the sides, as shown at *A* in *Fig. 18*. Now have some one with hair stand on the stool and suspend a metal plate over his head and connect this with the positive pole of your electric machine, as shown at *B*. When you turn the handle, his hair will stand on end, though not, perhaps, at his own wonders, as was said of Comus, the famous medieval magician.

Shocking Handles and Cords.—While the shocks are given by means of a static machine, the effects

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produced on the innocent bystander who happens to



A. The Insulated Stool B. The Experiment
Fig. 18. Making One's Hair Stand on End.

be connected with it are quite dynamic. The handles which are shown in *Fig. 19* are formed of two cylindrical tubes closed at one end, and to one of which is fixed an insulated handle. All you have to do to

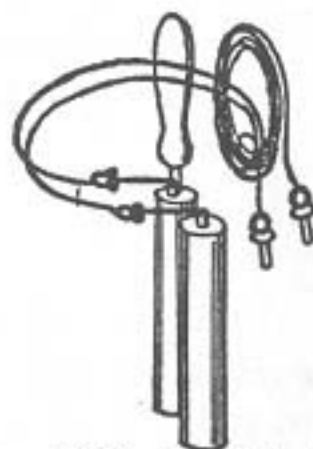


Fig. 19. A Pair of Shocking Handles.

test the physiological effects of electrical discharges is to plug in the cords to the positive and negative poles of your electric machine and then speed it up.

Smoke and Fog Condensation.—When an electric discharge takes place in either smoke or fog, they disappear entirely. You can try it experimentally, and

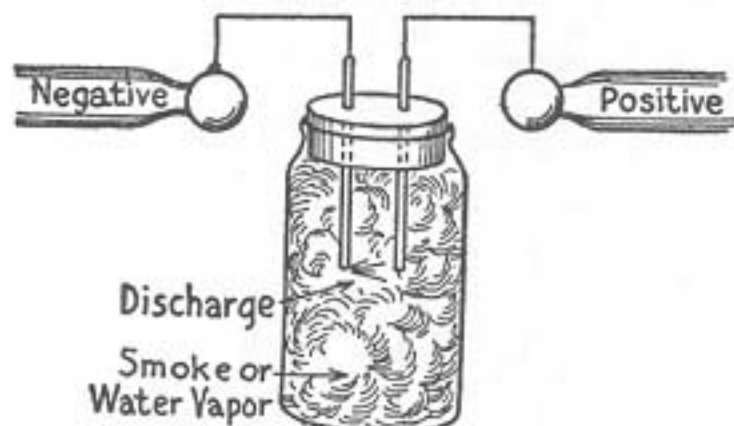


Fig. 20. Fog and Smoke Condensation Apparatus.

Sir Oliver Lodge produced some very remarkable results with a fog apparatus that showed real commercial possibilities. Get a large glass jar and fit a wood or hard rubber cover in its mouth. Drill two holes in

the cover and force a pair of wires, pointed at one end, in these so that they will be tight; have the two pointed ends separated an inch or so, and connect the other ends to your electric machine, as shown in *Fig. 20*. Now fill the jar with smoke or water vapor, and pass

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the discharge through it, when the particles of which it is formed will coalesce and fall to the bottom.

The Dancing Balls.—Drill, or have drilled, a hole through the bottom of a glass tumbler, and in this fit a wire that ends in a brass disk. Now place half a dozen pith balls inside of the glass, invert it on a metal plate and connect this with the earth. Connect the brass disk with the other pole of the machine, as shown

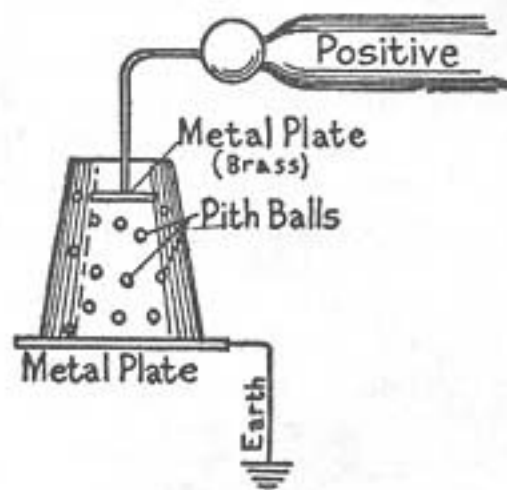


Fig. 21. The Dancing Balls.

in *Fig. 21*. When the latter is set in action, the balls will begin to dance up and down.

The Electric Chimes.—In this pretty experiment bells are rung by the attractions and repulsions of electro-static charges. The outside bells are connected by wires or chains to a strip of brass, and this in turn to the positive pole of the electric machine. The middle bell is suspended by a silk thread from the brass strip, and this is connected to the earth by a wire or chain. The little metal balls are supported by silk threads from the metal strip, and all of which is

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clearly shown in *Fig. 22*. Now, when the machine is in action, the outside bells attract the balls by inducing a charge in them, when they are repelled and strike the middle bell; this causes them to lose their charges, which are carried to the earth, when they are again attracted to the outside bells. In this way the bells will keep on ringing as long as the machine is kept going.

Franklin's Lightning Plate.—This is an experiment that you can easily make the apparatus for, and with which you can get some very wonderful effects. Get a sheet of glass and give one side of it a coat of

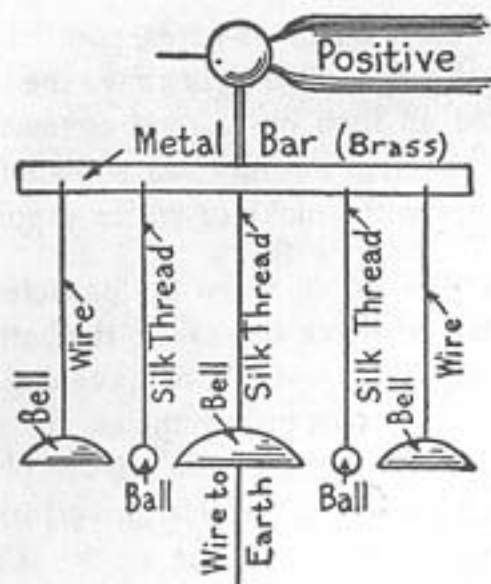


Fig. 22. The Electric Chimes.

shellac varnish. Before the shellac is dry, lay a strip of tinfoil about three-sixteenths of an inch wide on the surface of it, as shown in Fig. 23. Now, at distances apart of every inch or so, cut the tinfoil away so that a gap of about one-eighth inch is formed be-

tween the opposing ends. Finally, paint the other side of the glass a dead black, and you are ready for the experiment. Connect the ends of the plate with the

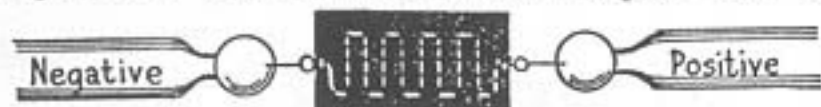


Fig. 23. Franklin's Lightning Plate.

poles of the electric machine, and turn the crank, when the sparks will jump across all of the gaps simultaneously.

The Geissler Vacuum Tubes.—These are glass tubes of various shapes and sizes, in the ends of which a pair of wires are sealed, as shown in Fig. 24. Be-



Fig. 24. Geissler's Vacuum Tube.

fore the tubes are sealed off, the air is pumped out of them and different gases are let in when these are pumped out to a certain extent. Now, when a high tension current is passed through them, beautiful luminous effects are produced. Some of the tubes are made in part of uranium glass, which fluoresces a green color under the electric discharge; then again, some of the tubes are enclosed by other and larger tubes, and the latter are filled with fluorescent solutions, such as fluoresceine, nigroscene, quinine, etc. Wonderful effects can be had by rotating these tubes, and all of which is explained in the chapter on "Some Experiments with Your Spark Coil."

The Electric Blowpipe.—If you will fix a pointed wire on the positive pole of an electric machine, as shown in Fig. 25, then put the latter into action and hold a candle close to the pointed end of the wire, the electric discharge will blow the flame away from it. This is called a *convective discharge*. By separating the spark gap points of an electric machine a little farther than the spark will jump, and by putting it into action in a dark room, each of the electrodes will give forth a pale blue light. This is known as a *brush discharge*, or *corona*. At the same time you will hear a peculiar hissing sound, which has been called the

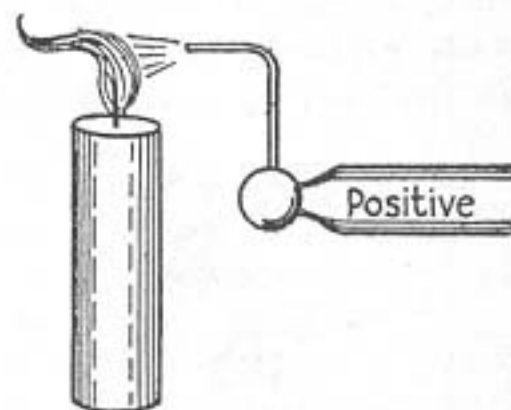
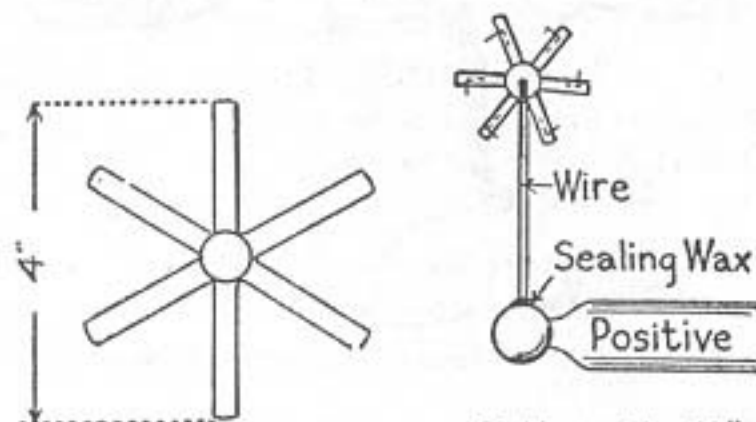


Fig. 25. The Electric Blowpipe.

electric wind. A convection discharge can only be had from a pointed wire, and if this is mounted so that it is easily movable, the force of the discharge will react on it and tend to push it away. This is the basis of the next two electric motor experiments.

The Electric Flyer.—This interesting piece of apparatus consists of a wheel, which is rotated by the reaction of the convection streams from its points when it is connected to the positive conductor of an electric machine. An easy way to make the flyer is to cut a disk out of cardboard about four inches in diameter, and paste a sheet of tinfoil on one side of it;



A. The Spokes Covered With Tin Foil

B. How the Wheel is Energized

Fig. 26. The Electric Flyer.

on the other side mark out six radial bars and then cut out the intervening spaces, when you will have a spoked wheel, as shown at *A* in *Fig. 26*.

This done, push a pin through the end of each bar and bend the pointed end of each pin over, so that they will all point in the same direction. Next, bend over one end of a thin wire and run it through the center of the wheel for a shaft, and fasten the other end to the positive pole of your electric machine with a little sealing wax, as shown at *B*; now turn the crank of the machine, when the wheel will rotate at high speed. If you will make the experiment in a dark room, the brush discharge from the rotating points will look like a ghostly crown of light.

The Electric Traveller.—This is a modification of the electric flyer just described, but instead of its

rotating on a wire it rolls along a level track or even climbs a grade. The wheel itself is made in accordance with the instructions given in the foregoing experiment, but the spindle is made of a sewing needle, which is secured to the wheel with sealing wax. Now make a track by fixing two wires, twelve or eighteen inches long, to the tops of four bottles with sealing wax, and separate these wires by about three-quarters of an inch, as shown in *Fig. 27*. Now connect the

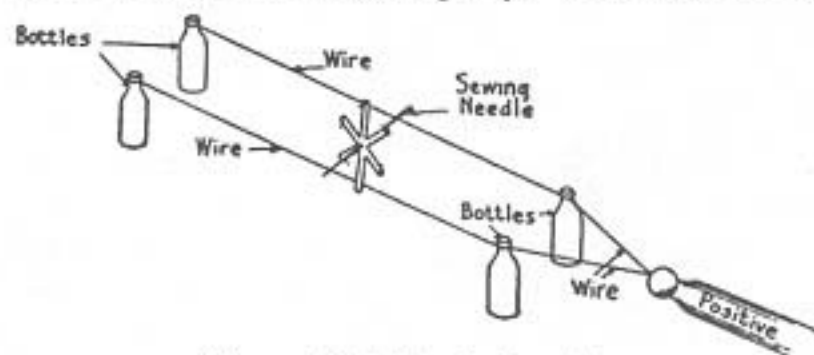


Fig. 27. The Electric Traveller.

track with the positive pole of your electric machine, lay the spindle of the wheel on the parallel wires, and when it is energized it will roll merrily along.

A Simple Static Electric Motor.—This motor works on an entirely different principle from the flyers described above, in that the rotation is caused by the attraction and repulsion of the electromotive forces set up by the electric machine. In making the motor, care must be taken to have the revolving element, or rotor, as it is called, as light as possible and well balanced, so that it will run true.

To make the motor, get a board one-half or one inch thick, eight inches wide, and fourteen inches long, and mount four sticks of sealing wax on it for the

standards, or supports; have the pair which are to support the wheel three inches apart, and fasten a glass bead to the top of each one. Have the other two standards nine inches apart, and mount two hollow brass balls on top of them.

For the rotor you will need a small cork, six pieces of straw three inches long, and six celluloid balls about one inch in diameter. Coat all of these with

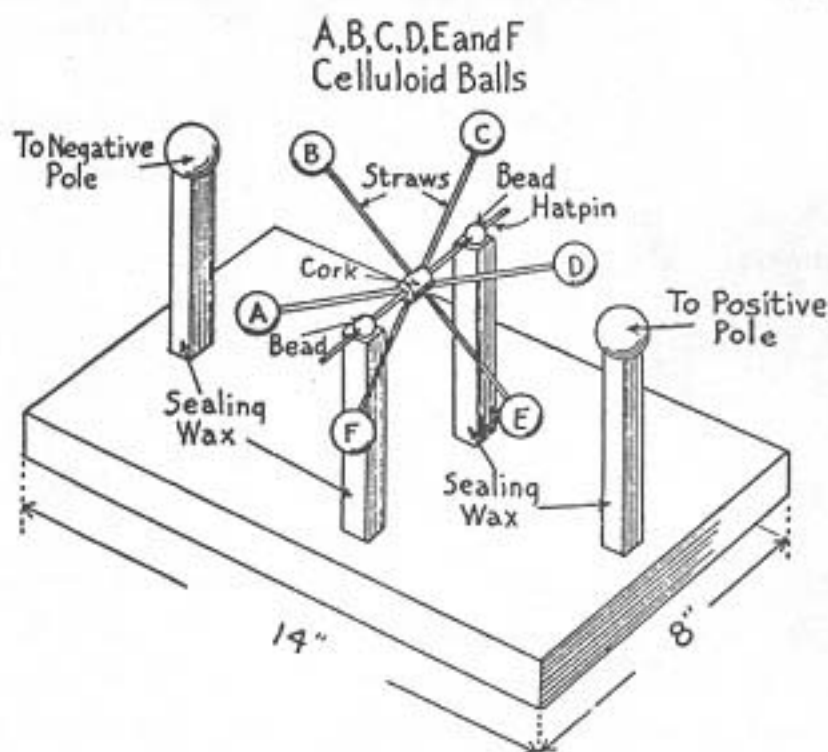


Fig. 28. An Easily Made Static Motor.

shellac varnish, and then give the balls a couple of coats of gold paint. Run a hat-pin through the cork and fix the straws at equidistant points around and on it, and the celluloid balls to the free ends of these, which you can do by using sealing wax, or some other good adhesive. Now slip the hat-pin through the beads on the standards, when the motor will be complete, as shown in *Fig. 28*.

Finally, oil the bearings with sewing machine oil, and connect the brass balls on the standards with the poles of your electric machine; turn away on the latter, when the rotor of the motor will turn rapidly.

III

ABOUT VOLTAIC, OR CURRENT ELECTRICITY

WHEN a spark passes between the cover of an electrophorus and your knuckle, or the end of a discharger and the inside coating of a Leyden jar, or the spark gap of a frictional or an induction machine, the electricity is no longer a *charge*, that is, *at rest*, but it is a *current*, that is, it is in *motion*. An electric current that is set up by the discharge of an electric charge is,

however, of very short duration, and in order to produce a continuous current, other means must be used.

Now, there are several ways by which a continuous current can be generated, and chief among these is chemical action, as in a cell or a battery, heating two opposite metals, as in the thermo-electric couple, and making a wire cut through a magnetic field, as in the dynamo. In Chapter I, you were told that current electricity was discovered in 1800, and this is how it all came about.

The Discovery of Voltaic, or Current Electricity.—In the year of 1780, the good wife of Luigi Galvani, a professor at the University of Bologna, Italy, skinned some frogs' legs preparatory to frying them for the family meal. In those days the laboratory and the living-room were about one and the same thing, and Madame happened to set the pan down that contained the frogs' legs close to a frictional machine, with which two of the professor's students were experimenting.

While one was turning the handle, the other, accidentally, or on purpose, caused a spark to pass from the machine to the frogs' legs. The professor's wife was not a little startled when she saw that every time a spark passed, the frogs' legs struck out for all the world as though they were alive and kicking. Amazed at this performance, Galvani tried many experiments with frogs' legs after that, and, finally, he put some copper hooks in them and hung them on an iron railing. As he did so, he observed that every time a copper hook touched the iron railing, the legs gave a lifelike kick; this remarkable action convinced Galvani that the frogs' legs generated electricity.

Now, there lived at the same time another Italian professor, who was also famous; this was Alessandro Volta, and he had already shown his ingenuity by having invented the electrophorus and the electroscope. He believed, with Galvani, that the frogs' kick was caused by electric action, but he differed with him as to the way in which it was generated. Volta's idea of it was that it was set up when the copper came in contact with the iron. This was a closer guess than that of Galvani, but it was not the real solution.

The Invention of the Electric Battery.—Working upon the theory that when two metals made contact with each other electricity was generated, Volta cut out a number of disks of copper and of zinc, and built them up into a pile by alternating the two metals and separating each pair with a disk of flannel, which he had soaked in a dilute solution of sulphuric acid.

Now, when he fastened a wire to the copper disk on the bottom of the pile and connected it with the zinc disk at the top of the pile, a current of electricity flowed through the circuit. Unlike the discharge of a Leyden jar, it was not a momentary current, but instead it flowed continuously for some time. This apparatus was the first electric battery, and since Volta was the first to produce a continuous current of electricity, this form of it has since been known as Voltaic electricity. The Voltaic pile, which was the first battery, is shown at A in Fig. 29, and it was made and used by Volta in 1800.



A. The Voltaic Pile B. An Electric Cell and Galvanometer

Fig. 29. The First Battery and a Simple Electric Cell.

How to Make a Simple Battery Cell.—An electric cell consists of a single rod, or plate, of copper, or carbon, called the *positive electrode*, and a single rod, or plate, of zinc, called the *negative electrode*, immersed in an alkaline, or an acid solution, called the *electrolyte*. When you connect two or more cells together, you have an electric battery.

To make a simple demonstration electric cell, get a strip of copper and one of zinc, each *one* inch wide and *four* inches long, and solder a copper wire to one end of each one, as shown at B. Next fill a tumbler

three-quarters full of water and add a dozen drops of sulphuric acid to it, and stir with a glass rod or a clean stick. This done, set the copper and the zinc strips into it. If now you will bring the ends of the wire together, a current will flow through them in the direction of the arrows in the illustration.

There are several ways by which you can detect the presence of the electric current flowing through a circuit, and among these are (1) to touch the ends of the wires on your tongue, when you can *taste* it; (2) to connect one of the wires with one of the binding posts of a telephone receiver, when you can hear it click; (3) to connect the free ends of the wire with a *galvanometer*, when you can see the needle move, and,

finally, (4) to connect it with an electric bell, when the latter will ring.

¹ The way to make a galvanometer is described in Chapter V.

How a Dry Cell is Made.—The best known kind of an electric cell to-day is the *dry cell*, or *dry battery*, as it is sometimes called, though improperly, for a battery consists of two or more cells coupled together. The dry cell is used for all sorts of purposes where an intermittent current of low voltage (pressure) and considerable amperage (quantity) is needed, and where it must be moved around.

The dry cell is only a modification of the simple electric cell just described, and it is called a dry cell, not because it is really dry, but in virtue of the fact that it is hermetically sealed, that is, it is made water tight, so that the electrolyte cannot leak out in any position.

A dry cell consists of a cylindrical cup made of sheet zinc, to which a binding⁴⁵ post is soldered; the active mixture, or *electrolyte*, is made of a paste composed of one ounce of zinc oxide, one ounce of zinc chloride, one ounce of ammonium chloride, three ounces of plaster of Paris, and two ounces of water. A carbon rod is then held in the middle of the cup, and the active paste is packed in around it, as shown at A in Fig. 30, while the cell complete is shown at B.

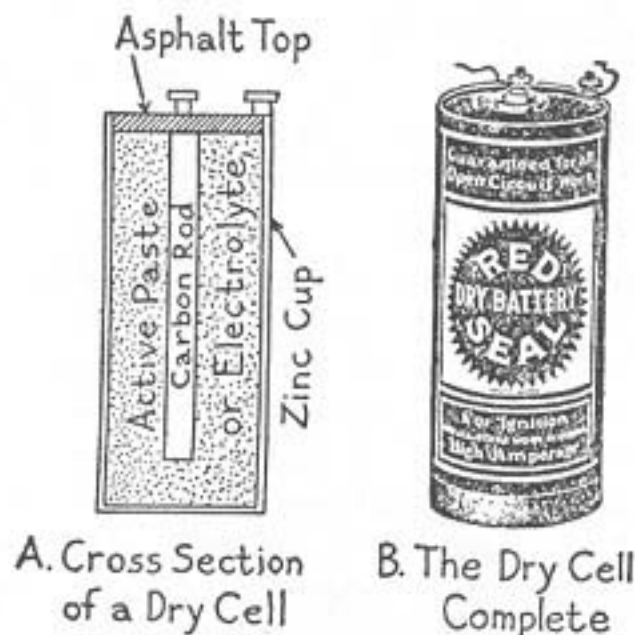


Fig. 30. How the Dry Cell is Made.

A fresh dry cell will give a current of from four to six amperes at one and a half volts. The current strength, or amperage, falls away very fast when it is used, and in order for it to recover, the circuit must be broken. This is the reason it is good only for open circuit work, that is, where a current is needed only for short periods and then at intervals.

How the Le Clanché, or Sal Ammoniac Cell is Made.

Where a cell is used for electric bell and other open circuit work of a like nature, and it does not have to be moved about, a Le Clanché, or sal ammoniac cell is often used. In its present form it consists of a mixture of manganese dioxide and coke (which is a kind of carbon) pressed into a cylindrical form.

A porcelain insulator sets in a hole in the top of the carbon cup, and a zinc rod is slipped into and through this. The element, as this part of a cell is

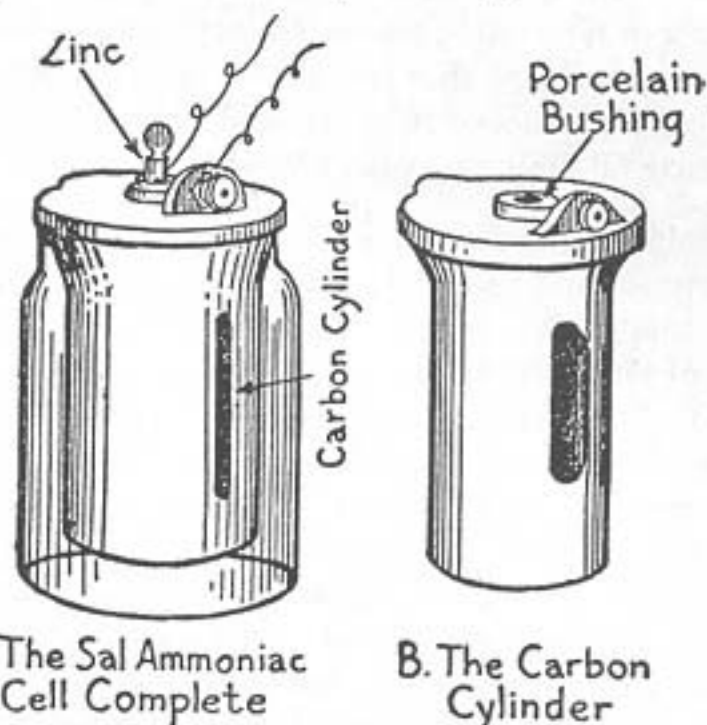


Fig. 31. The Sal Ammoniac or Carbon Cylinder Cell.

called, sets into a glass jar partly filled with a solution made by dissolving four ounces of sal ammoniac, that is, ammonium chloride, in one quart of water. It is shown in Fig. 31.

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The Gravity, or Crowfoot, Cell.—This cell has long been in use for working telegraph lines, and it is peculiarly well adapted for this purpose, for the reason that the circuit must be kept *closed*, that is, constantly generating a current, to keep it in good condition, instead of the circuit having to be kept *open*, as in the dry and sal ammoniac cells just described.

The cell consists of a star shaped electrode formed of strips of copper riveted together; this is placed in the bottom of the jar, and from this a rubber insulated wire leads up to the top and outside of the jar. Supported by the top of the jar, is a pronged cast zinc electrode that looks somewhat like a crow's foot, hence the name *crowfoot* cell. It is shown in Fig. 32.

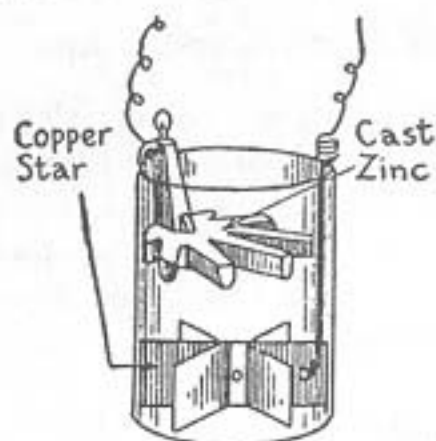


Fig. 32. The Gravity or Crowfoot Cell.

The solution, or electrolyte, is made by putting some crystals of blue vitrol, that is, copper sulphate, around the copper star and then pouring in enough water, into which a few drops of sulphuric acid have been stirred, to nearly fill the jar. Now, when the circuit is closed,

the sulphuric acid acts on the zinc, and zinc sulphate is formed, and as the density of this solution is less than that of the copper sulphate solution in the lower part of the jar, it floats on top. This difference in the specific gravities of the two solutions is the sufficient cause of its being called a gravity cell.

If the cell is left on open circuit for some time, the two solutions will mix and the copper sulphate will be deposited on the zinc; when this happens, the only way, then, to get the cell into working order again is to short circuit the electrodes for several hours, and this is done by connecting the zinc element directly with the copper electrode.

How the Bunsen Cell is Made.—While any of the above cells will do for demonstrating electroplating with copper, a Bunsen cell is the kind to use for real plating, for it gives a large and fairly constant current for a long time. This cell differs from the others in that the electrolyte consists of two separate liquids. The first of these is a dilute solution of sulphuric acid, and this is poured in the glass jar, while the other is concentrated nitric acid, and this is poured into a porous cup.

A carbon electrode is now placed in the porous cup, and the latter is set in the glass jar; then a cylindrical zinc electrode is put over the porous cup and down into the jar, when the cell, which is shown in Fig. 33, is ready for action. To keep the cell in good working order, the electrodes must be cleaned as soon as you have used it for any length of time, and the acids renewed whenever they become discolored.

How the Bichromate Cell is Made.—This cell is

very useful for all kinds of experimental work where a powerful current is needed for a short time. A bichromate cell delivers about two volts, and by connecting two or more cells in series, or in multiple, a

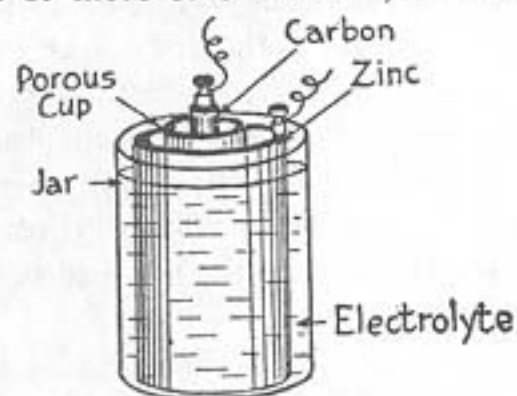


Fig. 33. The Bunsen Cell.

higher voltage or a larger amperage can be had, and the way to do this will be explained presently. Different from the foregoing cells, except the Bunsen cell, the chemical action of the electrolyte of the bichromate cell on the zinc is very active, and, hence, the zinc electrode must be lifted out of the solution every time you are through using it. As you must lower the zinc into the electrolyte when you want to use it, a battery made up of these cells is called a plunge battery.

The electrolyte is made by dissolving one pound of powdered bichromate of potash in one gallon of hot water and stirring with a stick until the latter is thoroughly dissolved. When the solution is cold, pour one pint of sulphuric acid *very slowly* into it, and stir it all the time that you are doing so. *Under no circumstances, pour the solution into the sulphuric acid.*

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Why the Zinc Must be Amalgamated.—In all of the cells described above, the zinc used for the negative electrode is always full of impurities, and hence the moment the electrolyte begins to act on them, little electric currents are set up between the particles of pure zinc and the impurities, and this is what is called *local action*. To prevent this wasteful action from going on, the zinc must be *amalgamated*, and this is done by coating it with a film of mercury.

To amalgamate the zinc, clean it thoroughly with a cloth dampened with dilute sulphuric acid, and then pour a very little mercury on the surface of it and rub it in with the cloth until it is entirely coated over, when it will look like a mirror. When the zinc is amalgamated, the mercury surrounds the particles of impure matter and so prevents the electrolyte from acting on them.

How to Make a Plunge Battery.—You can buy a student's four-cell plunge battery for about five dollars, or you can make one for about half this amount. I will explain how one cell is made, and then you can make two, three, or four cells, or as many as you need. Get one zinc plate and two carbon plates one-quarter inch thick, one and three-quarters inches wide, and four inches long, and drill a three-eighths inch hole through all of them near one end, as shown at *A* in Fig. 34.

This done, push a piece of fiber tube three-eighths of an inch in diameter, and one and one-quarter inches long, through the zinc plate, then put a one-quarter inch thick fiber washer over each end of the tube; next, put a carbon plate over each end of the tube,

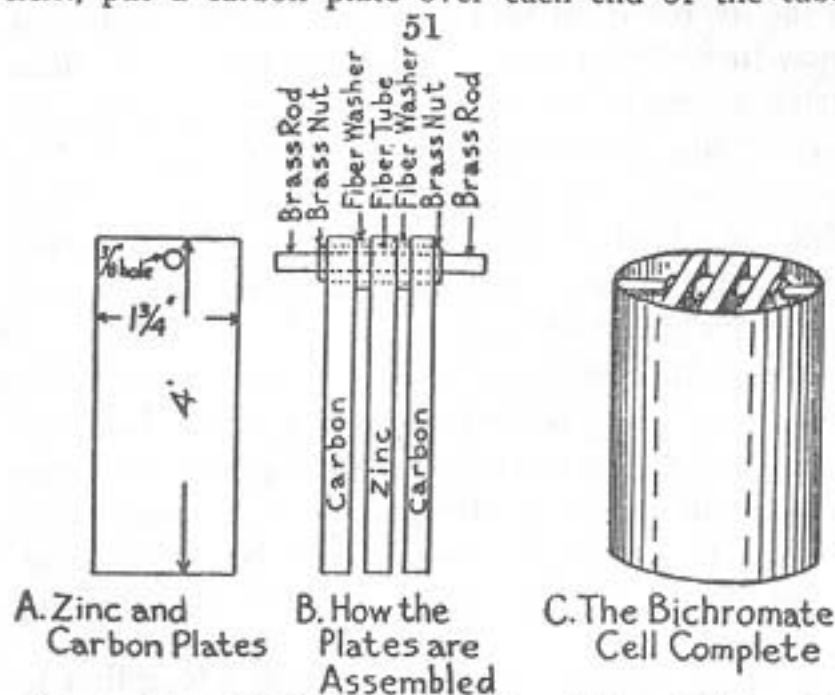


Fig. 34. How the Element of a Plunge Battery is Formed and the Cell.

and then push a brass rod one-eighth inch in diameter and three inches long, with threads cut on it one inch down on both ends, and screw a nut on each end, when the element will be assembled, as shown at *B*.

Now, if you want a four-cell battery, make a wooden rack to set the cells in; this you can do by getting a board one inch thick and six and one-half

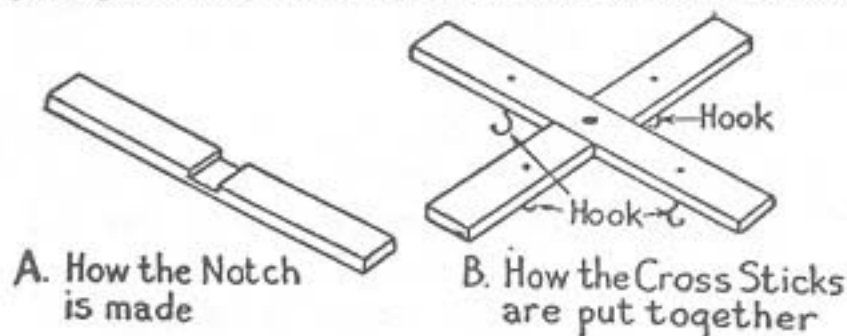
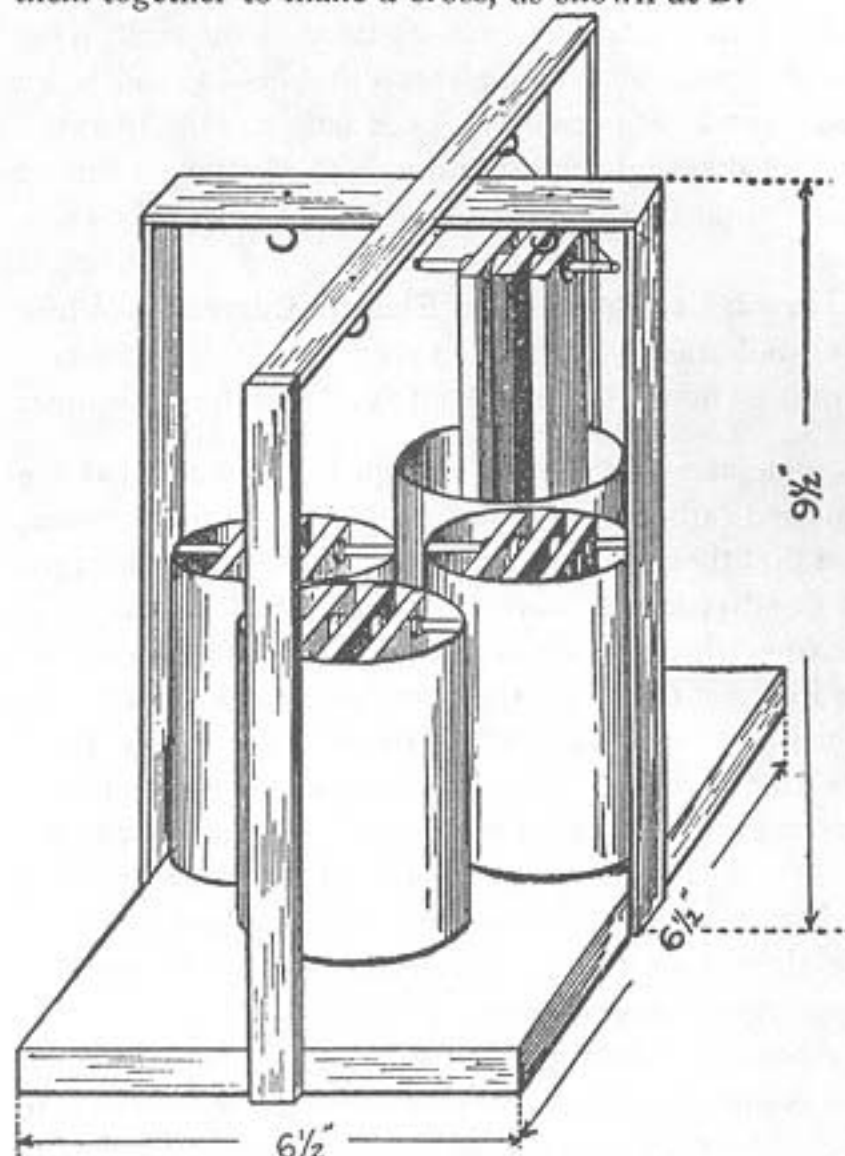


Fig. 35. The Top of the Battery Rack.

of wood half an inch thick, one inch wide, and six and one-half inches long, and cut out a notch in the middle of each one a quarter of an inch deep and one inch wide, as shown at *A* in Fig. 35, and then set and screw them together to make a cross, as shown at *B*.



C. Fig. 35. The Battery and Rack.

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This done, get four sticks half an inch thick, one inch wide, and nine inches long, and screw these to each side of the base in the middle, and screw the ends

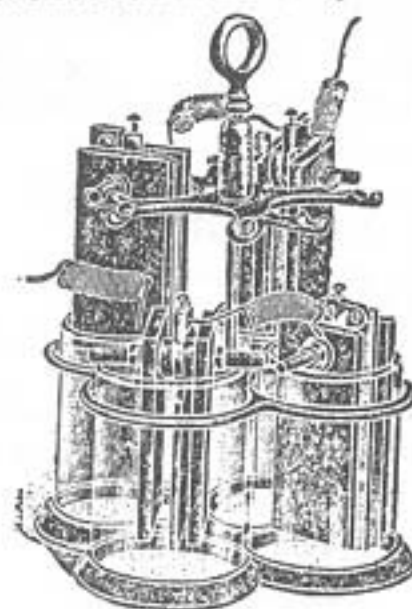


Fig. 36. A Four Cell Students' Plunge Battery.

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inches on the sides for the base; next, get two strips

of the cross sticks to the upper and tree ends, all of which is shown at *C*. Now screw a pair of hooks into the cross sticks half-way between the middle and the ends of them, as shown at *B*, and your rack is finished.

Finally, fill the tumblers three-quarters full of the bichromate electrolyte, and set them in the rack; hang the elements up by their respective hooks, and when you want to use them you need only to take them off and set them into the solution. The battery complete is shown at *C*, while the one that you buy is shown in *Fig. 36*.

How a Cell Sets Up an Electric Current.—While the whole theory of how an electric cell sets up a current is an hour's story and not at all easy for a beginner

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to understand, it will be enough to say here that the zinc and carbon elements of a cell are built up of *atoms*, and that these, in turn, are made up of minute charges of negative and positive electricity called *electrons*.

Now when the electrolyte, that is, the alkaline or acid solution, acts on the zinc, the negative electrons, which are negative charges of electricity, flow from the zinc atoms to the carbon atoms in a continuous stream; from the latter they pass to the outside circuit, and those that have not been used up in overcoming resistance or in doing useful work, flow back again to the zinc element. So, an electric current is really a discharge or flow of negative electrons.

About the Storage Battery.—A storage battery cell is different from a primary battery cell, in that it does not set up a current by a primary chemical action, but by a secondary chemical action. In other words, before a storage battery cell will deliver a current, it must be charged by a current. Different from a primary cell, a storage battery cell is formed of two lead electrodes,* instead of zinc and carbon electrodes. Now, you can make a simple storage battery cell, which will demonstrate the way the practical ones that are in use work, very easily.

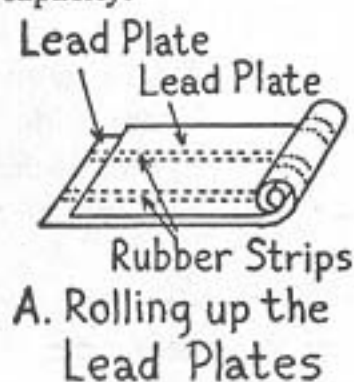
*The Edison storage battery cell is an exception, as it uses an element formed of nickel and steel plates.

The Invention of the Storage Battery.—More than sixty years ago, that is to say, in 1859, R. L. G. Planté, of France, found that when two lead plates were immersed in a dilute solution of sulphuric acid and a current from a primary battery was made to flow through the cell so formed, the latter would, in

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turn, deliver a current. On this experiment is based the storage battery of to-day. In a further experi-

ment, Planté rolled up two strips of sheet lead with a couple of strips of rubber between them, as shown at *A* and *B* in *Fig. 37*, and so made a cell of larger current capacity.



A. Rolling up the Lead Plates



B. The Lead Plate Element

Fig. 37. The Planté Storage Battery Cell.

Now to follow the next experiments, which resulted in the improvement of the storage battery, you must know that when a current is flowing between the lead plates, hydrogen is set free on the negative plate, and part of this changes the film of lead oxide that is formed by the air on the surface into spongy lead, which is a kind of metallic lead. The charging current fixes oxygen on the other and positive plate, and this forms a film of lead peroxide on it.

If now the charging current is reversed, the spongy lead of the first plate will be changed into lead peroxide, and the lead peroxide of the second plate into spongy lead. To make the plates take a large charge, so that it would give an equally large discharge, Planté found it necessary to reverse the charging

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current many times, and, hence, it took a long time to form the plates.

The next advance was made by C. A. Faure, also of France, in 1881, when he formed the plates by pasting them over with red lead, and this did away with the tedious process of forming them with a primary battery current. In his battery Faure used sheets of felt to separate the plates. While Faure's method saved time and was much more economical than that of Planté, still the red lead would disintegrate and fall off, and so put an end to the usefulness of the battery.

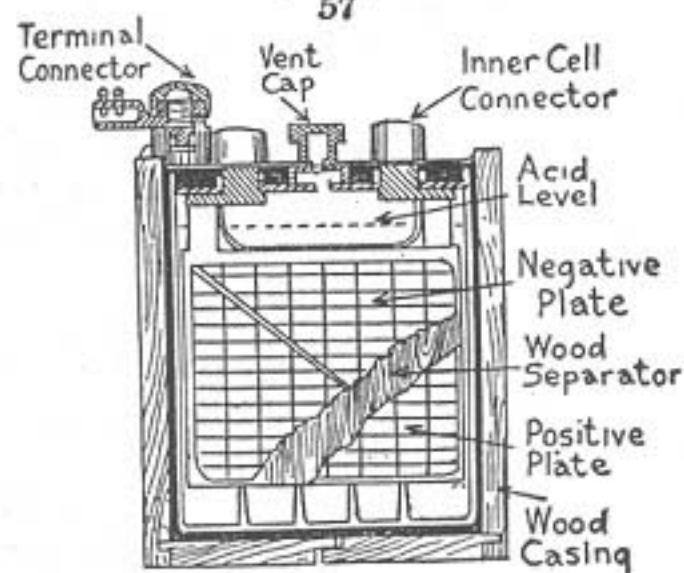
To overcome this objection, other inventors made *grids* of the plates by punching them full of holes, or casting ribs on them, or cutting grooves in them, and then filling the spaces of one plate up with spongy lead, and those of the other plate with lead peroxide. This construction formed a good mechanical support, and so holds the active material in very well. The grids in present day batteries are kept at the proper

distance apart with wood separators

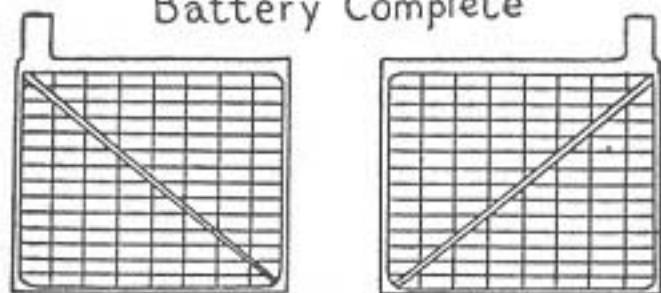
How to Make a Simple Storage Battery.—All you need to do to make a simple storage battery cell is to get two strips of one-eighth inch thick sheet lead, one and three-quarters inches wide, and four inches long, and solder, or otherwise fix, a wire to each one; screw these to the opposite sides of a strip of wood half an inch thick, one inch wide, and three and one-half inches long, and place the element so formed in a tumbler nearly filled with water, into which you have put a few drops of sulphuric acid.

To charge the storage cell, connect one of the strips

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Sectional View of Storage Battery Complete



A.-The Positive Plate B.-The Negative Plate

Fig. 38. How the Storage Battery is Made.

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of lead with one of the poles of your primary battery, and then close the circuit by holding the other wire of the battery on the other strip of lead. You need only to keep the circuit closed for half a minute, when enough energy will be stored up to ring an electric bell or to light up a two-volt lamp.

The Commercial Storage Battery.—Different from a primary battery, a storage battery delivers a large and constant current as long as the charge lasts, and for this reason the latter is used where it is not practicable to use the former, and where engines and dynamos cannot be installed as, for instance, on

motor cars, or where the latter power plants cannot be run continuously, as on submarine boats. Small storage batteries that develop about six volts are largely used for heating the filaments of vacuum tubes for wireless telegraphy and telephony. The positive grid of a commercial storage battery cell is shown at A in Fig. 38; the negative grid at B, and the cell complete at C.

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IV

SOME EXPERIMENTS WITH CURRENT ELECTRICITY

IN the chapter ahead of this one, I told you how to make various kinds of cells and batteries for generating current electricity, and in this chapter it is my intention to tell you how you can make a number of simple but highly interesting experiments, which need little or no special apparatus.

How to Make an Electric Spark.—To see a spark made by a battery, you will have to do the experiment in a dark room, or else perform it at night. All you need to do is to bring the two ends of the wires that are connected with a battery of three or four cells together, and then draw them apart, that is, break the circuit, when you will see a small, bright spark.

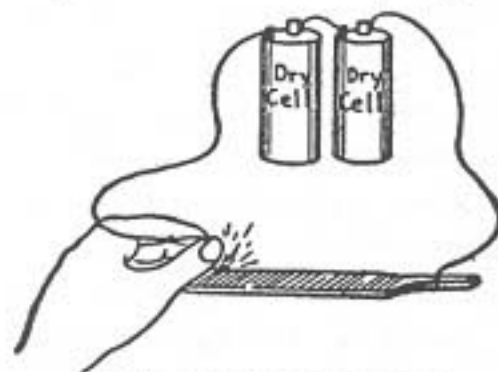


Fig. 39. How to Make Sparks.

How to Produce a Succession of Sparks.—To make a lot of sparks in succession, it is only necessary

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to connect one post of your battery with the tang, or handle end, of a medium cut file, and draw the free end of the other wire, which leads to the other post of the battery, across the teeth of it, when you will see a succession of brilliant little sparks as the circuit is made and broken. How to do it is shown in Fig. 39.

How to "Taste" Electricity.—While electricity itself has no taste, when you touch the ends of the wires from your battery to your tongue, you will *sense* a taste that is quite sour. This is the result of a chemical action set up by the current in your mouth. As a battery develops only a few volts, you can safely

perform the experiment, as you cannot possibly get a shock.

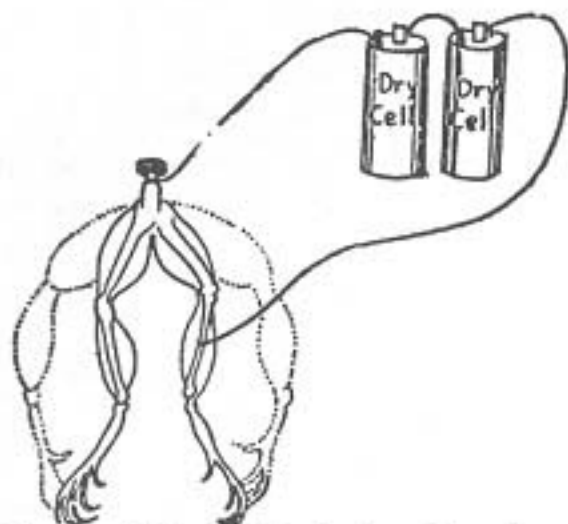


Fig. 40. Galvani's Frog's Legs Experiment.

Galvani's Frog's Legs Experiment.—It was a pair of frog's legs that led to the discovery of the electric current and the invention of the electric battery, as I explained in the foregoing chapter, and here is a slight modification of the original experiment that you can

do. Get a pair of fresh frog's legs, skin them, and then touch the nerves of them at the points shown in Fig. 40 with the ends of the wires from your battery, when they will give a convulsive kick.

A Miniature Electric Light Plant.—Buy a little two-volt electric lamp of the kind used for flash-lights, and also a socket to fit it. Screw the lamp into the socket and then connect a wire to each of the screws of the latter and lead them over and fasten them to the posts of your battery, when the current will heat the filament of the lamp to brilliancy.

A cell of any kind develops about one and a half volts, so you must never use more than two cells to light up a two-volt lamp, or it will burn it out. Fur-

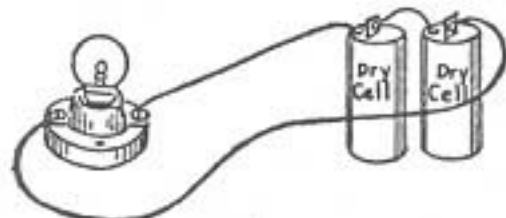


Fig. 41. A Miniature Electric Light Plant.

ther, do not keep the lamp lit up too long at a time, for if you do, it will quickly run down your battery. To turn off the current, you need only unscrew the lamp a little in its socket, and when you want to light the lamp again, screw it down a little. The way the lamp and battery are connected up is shown in Fig. 41.

To Dim the Light With a Water Resistance.—In its simplest form, a water resistance consists of two

electrodes of like materials, such as zinc, copper or carbon, immersed in a slightly alkaline solution. It is used to regulate the amount of current that is flowing

from a battery or other generator. To make a water resistance, put a teaspoonful of common table salt into a tumbler of warm water, and stir it with a stick, or a glass rod, until it is dissolved.

Now cut out a strip of heavy pasteboard, so that it is two inches wide and three and one-half or four inches long, and make two holes in it one and one-half inches apart, which are just large enough so that a pair of carbons, about three inches long, (electric light carbons will do) will slide through them. Twist a piece of bare copper wire around one end of each carbon, and connect one of them to one post of your battery; connect the other one with one of the screws of the lamp, and the other screw of the latter with the other post of the battery, as shown in Fig. 42.

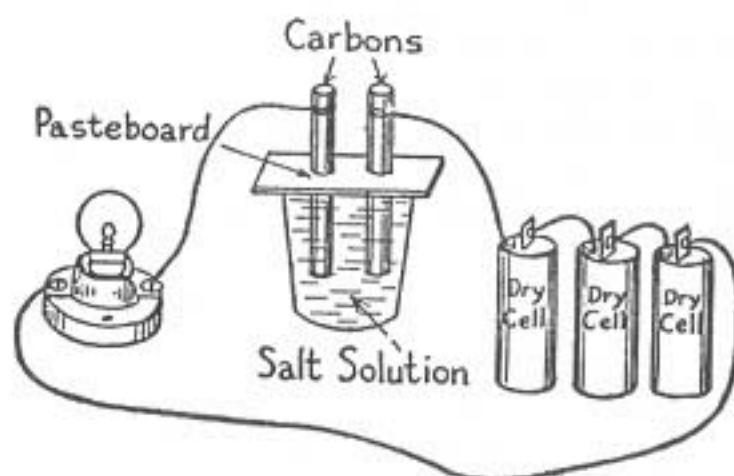


Fig. 42. A Water Resistance Dimmer.

Now, by either raising or lowering the carbons so that a smaller or a larger amount of surface remains in the solution, or by changing the distance between the carbons, the resistance of the circuit will be varied

accordingly. It follows, then, that by raising the carbons, the light will be dimmed, and by further immersing them in the solution, the light will grow brighter.

How to Make a Flash-light Telegraph.—With this little apparatus, you can either signal at night over quite a distance, or you can telegraph, provided you know the Morse Code. All that you require besides the electric lamp and a couple of dry cells, is a strap-key, as it is called, and this you can easily make.

Get a piece of wood half an inch thick, two and one-quarter inches wide, and three and one-half inches long, and bore four one-eighth inch holes in it. Now

cut a strip of tin, or, better, a strip of spring brass, three-eighths of an inch wide, and two and three-quarters inches long, and drill, or punch, a hole in each end. Bind it up and over at one end about three-eighths of an inch, and screw a knob—the head of a clothes-pin will do—to the opposite end.

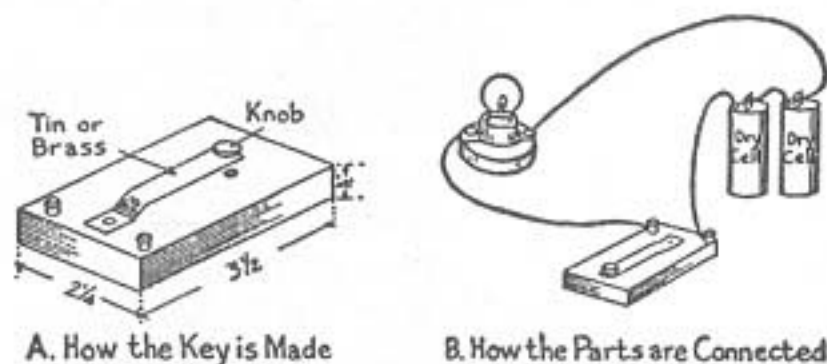


Fig. 43. A Flash-Light Telegraph.

Fasten the bent end of the strip down to the board with a machine screw and nut, and directly under the screw that holds the knob to the free end, which should come over the hole, put in another machine screw for the fixed contact point. Next, screw two binding posts to one side of the board and connect the fixed contact screw to one of them, and the fixed end of the lever to the other one, all of which is shown at A in Fig. 43. Finally, connect the lamp, the key and the battery together, as shown at B, and you are ready to signal or to telegraph.

Now, when you and your pal want to signal each other, let one flash mean "No," two flashes mean "I don't understand," and three flashes mean "Yes." To telegraph, you and your pal must learn the Morse Code, which is given in the chapter on The Telegraph and Telephone, or, better, the International Morse Code, or General Service Code, as it is usually called, which is given in the chapter on Wireless Telegraphy and Telephony, as this is the code of dots and dashes that is now in use all over the world by wireless operators, and when you learn this you will be able to send and receive wireless messages as well.

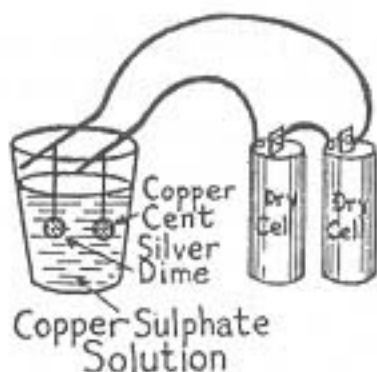


Fig. 44. Electroplating With Copper.

How to Electroplate With Copper.—This is a simple experiment that shows how one metal may be deposited on another by electricity, or *electroplating*, as it is called for short. Put a tablespoonful of copper sulphate into a tumbler of warm rain water and stir it until it is thoroughly dissolved; now place the ends of the wires from your battery across the top of the tumbler, as shown in Fig. 44.

This done, take a silver coin, or any other small silver or brass object, and boil it in vinegar until the dirt and grease have been removed from its surface. Next, rinse it in water and bend a thin copper wire around it and hook it on to one of the battery wires. Take a copper cent, or a small piece of pure copper, and cut the grease off of it, and hang this on the other battery wire.

It will not be long before you will see that the silver coin, or object, is taking on a dull reddish color, and this is the copper that is being deposited on it. The longer you leave it in the plating bath, as the solution of copper sulphate is called, the thicker will be the deposit of copper on it. To give the film of copper a polish, rub it with an ordinary pencil eraser.

How to Decompose Water.—Water is formed of two gases, which are hydrogen and oxygen, chemically combined, in the proportion of one part of the former to two parts of the latter by volume, that is, by bulk. Here is an experiment that you can make to prove it. Fill a tumbler with water, and then put a few drops of sulphuric acid into it, for ordinary water will not conduct an electric current well, but acidulated water will. Take two pieces of carbon rod, about one-quarter inch in diameter and one inch long, and twist the end of a one-foot length of copper wire around the

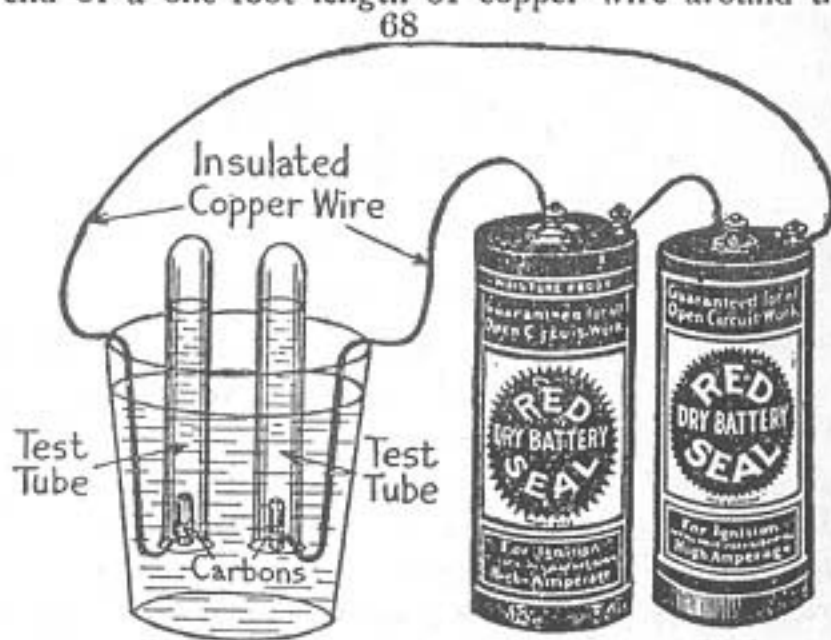


Fig. 45. The Electrolysis of Water.

end of each one, and set them in the water, as shown in Fig. 45.

The next step is to fill two test-tubes with acidulated water from the tumbler, and then invert them, that is, turn them upside down, in the tumbler of water over the carbon electrodes. Instantly, you will see that the water in the upper ends of the tubes is falling and, further, that it falls twice as fast in one tube as it does in the other. The water falls in the tubes because the gases formed by its decomposition rise in them and so displace the water; and the water falls twice as fast in one tube as in the other, because there is twice as much hydrogen as there is oxygen in the water.

You cannot see either of these gases, since they are both colorless, but you can easily prove that they are in the test-tubes, and, moreover, that one of them is hydrogen and the other is oxygen. To do this, first

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remove the tube that contains the least water and, hence, the most gas—which is the hydrogen tube, and keep the closed end up. Now hold a lighted match to the mouth of it, when the gas will explode with a sharp crack, and this proves it is hydrogen gas.

Finally, remove the other tube and keep the closed end up, as before; light a match, and when it gets to burning well, blow the flame out, but keep it kindled; now insert it into the tube, when it will instantly burst out into a flame again, and this proves that the gas in the tube is oxygen, for it supports combustion.

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V

MAGNETISM AND MAGNETS

Natural and Artificial Magnets.—There is a country in far-off Asia called *Magnesia*, and it was there that a strange kind of iron ore, known as *lodestone*, was first found. Now, the ancients discovered that this kind of iron ore had the peculiar property of attracting particles of iron to it, and since it came from *Magnesia*, it was called a *magnet*. Then, when steel was invented, it was found that by rubbing it with a piece of lodestone, or magnet, it would not only become *magnetic*, but remain so for a long time.

Kinds of Magnets.—There are two chief kinds of magnets, and these are (1) *permanent magnets*, and (2) *electro-magnets*. Just now, we are only concerned with permanent magnets, and of these there are two kinds, which named are (a) *natural magnets* and (b) *artificial magnets*. Iron ore, or lodestone, when

it is mined, forms natural magnets, and steel which has been made magnetic, either by contact with another magnet or by an electric current, forms artificial magnets.

When ordinary soft iron is magnetized, it loses its magnetic properties as soon as the magnetizing influence is removed, but when steel is magnetized, it retains its magnetic properties for an indefinite length of time. Steel magnets, or *permanent magnets*, as

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they are called, are made in different shapes, but the two most common ones are (1) the bar magnet, as shown at A in Fig. 46, and (2) the horseshoe magnet, shown at B. A horseshoe magnet is really a bar magnet bent in the middle so that its ends come closely together.

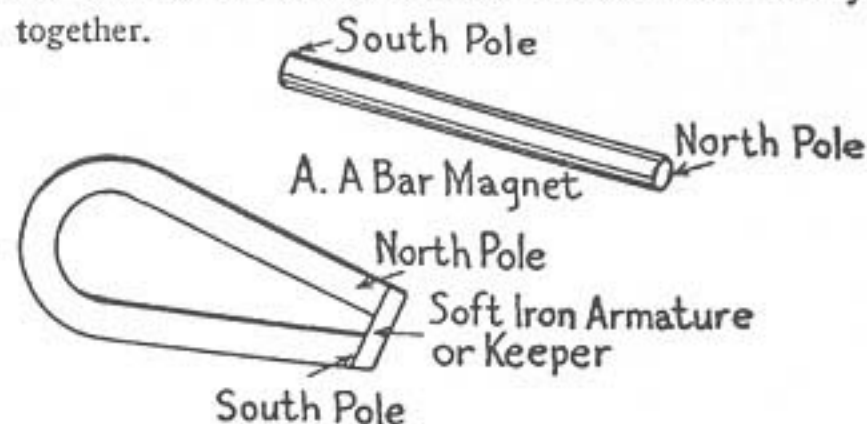


Fig. 46. Kinds of Permanent Magnets.

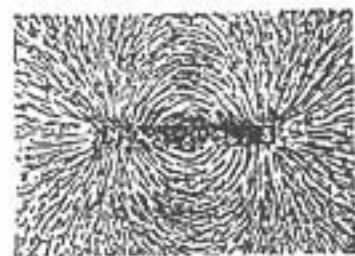
The Poles of a Magnet.—The first experiments ever made with a magnet, of which we have a record, were those of Dr. Gilbert, of Colchester, England, in about the year of 1600, and he published an account of them. It was he who found that the ends of a magnet had the greatest strength, and these he called the *poles*, while the middle, which had the least strength, he called the *neutral point*. You can easily prove this to your own satisfaction by laying a bar magnet on some iron filings, and then lifting it up, as shown at A in Fig. 47.

Magnetic Lines of Force.—Take, now, a sheet of thin cardboard, or glass, and hold your magnet

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A. The Poles of a Magnet



B. Magnetic Lines of Force



C. Magnetic Lines of Force in and around Bar Magnet

Fig. 47. The Action of a Bar Magnet.

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under and against it; then sprinkle, or better sift, some fine iron filings on top of the card or glass, and at the same time tap the edge of it with a lead pencil, when the filings will arrange themselves in curved lines, as pictured at B, and these show how the magnetic force joins the two poles together.

These lines of force, when taken together, are called the field of force, or just the magnetic field. The lines of force flow through the bar from the end which is called the south pole, to the other end, which is

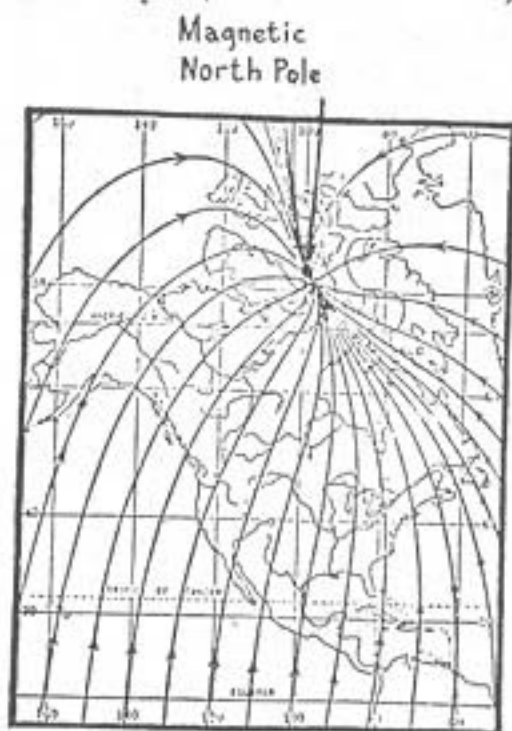


Fig. 48. The Earth is a Big Magnet.

known as the north pole, and from the latter they flow back to the south pole again *outside* the magnet, as shown at C, thus completing the magnetic circuit.

The Earth Is a Magnet.—The earth is a huge magnet, and the lines of force flow through it from

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the south pole to the north pole, and from the latter they flow back to the south pole outside of it, just as they do in the case of an ordinary magnet. The magnetic north pole of the earth is not at its geographical north pole, however, but is at a point in North America, close to where Latitude 70° North crosses Longitude 100° West, as pictured in Fig. 48.

The Magnetic Compass.—Since the earth is

magnetic, it makes it possible to find its magnetic north pole by means of a compass. This instrument, in its simplest form, consists of a very small steel bar that has been magnetized and is pivoted or otherwise supported, so that it can swing round freely.

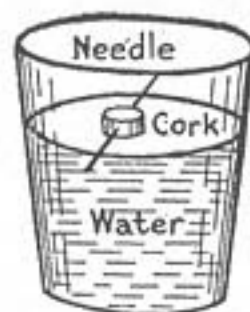
Thus, if you will tie a fine thread around the middle of a bar magnet and hold it, as shown at A in Fig. 49, you will find that it will turn round, so that one end is pointing north and the other end will of course point south. The end of the magnetized bar that points north is its south pole, but it is usually, though wrongly, called the north pole, because it points to the north pole. The reason it points to the north and south poles of the earth is because the magnetic lines of force that flow between these poles are strong enough to attract and to hold it, just as a steel magnet does.

How to Make a Magnetic Compass.—You can easily make a compass by drawing the head end of a sewing needle on the north pole of a bar, or horse-shoe, magnet, and the pointed end on the south pole of the latter. This done, run the needle through a small cork and place it in a tumbler of water, as shown at B, when you will have a very good compass.

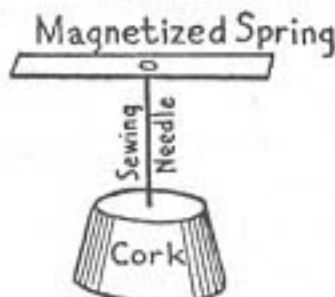
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A: A Magnet Acts as a Compass



B: A Simple Magnetic Compass



C: A Better Compass



D: A Real Compass

Fig. 49. Kinds of Compasses.

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To make a better compass, get a steel watch spring, about one and one-half inches long, and make a dent in the middle of it with a center punch. Then magnetize it by rubbing it on the poles of a permanent magnet, or, better, by electro-magnetic induction,

which I shall describe presently. Now stick a sewing needle into a cork, and place the compass needle on its point, as at *C*; or you can buy a sensitive compass (See *D*), which you can carry around with you, for as little as twenty-five cents.

How to Use a Magnetic Compass.—When you buy a compass, it will have a card mounted under it that is marked N, E, S and W, (north, east, south and west), and these are called the *cardinal points*. Half-way between it will be marked NE, SE, SW and NW (north-east, south-east, south-west and north-west). Your compass needle will, of course, tell you which direction north and south is, and to find all the other directions, you need only to turn your compass around until the letter N (north) comes directly under the point of your compass needle, as at *D*, when the other letters will then point to the other directions.

The Laws of Magnetism.—Just as like electrified bodies repel each other, and unlike electrified bodies attract each other, so, also, do like magnetic poles repel each other and unlike magnetic poles attract each other. To prove these laws, take two bar magnets and suspend them by threads, so that they can swing freely round their short axes.

Now bring both north poles close together, and you will see that they will repel each other. Next, bring both south poles close together, and you will see that

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they likewise repel each other. Finally, bring the north pole of one bar magnet close to the south pole of the other one, when you will see that they attract each other.

What Magnetic Induction Is.—Also, just as one electrified body acts on and electrifies another body without their being in actual contact, so one magnetic body will act on and magnetize another magnetic body without their coming into actual contact. Where such magnetic action takes place between two bodies, which are separated from each other a little, it is

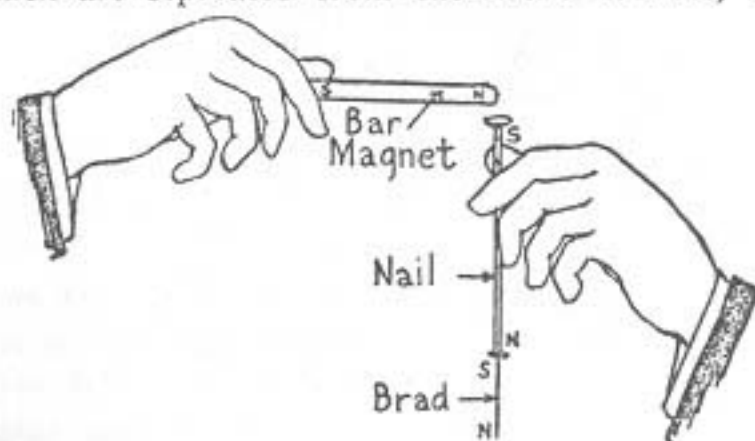


Fig. 50. Magnetism by Induction.

called magnetic induction.

It is by induction that the magnetic lines of force of the earth affect the compass needle, and you can easily show it by holding the pole of a bar magnet close to the end of a nail, when the latter will become magnetic and support a brad that you place on its end, as in *Fig. 50*.

Electro-Magnetic Induction.—While magnetism and electricity are not at all alike, still they are linked together very closely, and when you have one of them

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in action, the other one is bound to be present, and, moreover, you can change magnetic energy into electric energy, and the other way about, with the greatest freedom. This is because a line of magnetic force sets up little closed circles of electricity around itself, and an electric current sets up little closed circles of magnetism around itself. This means that a line of magnetic force is constantly changing a part of its energy into electricity, and an electric current is constantly changing a part of its energy into magnetism.

The Electro-Magnetic Field.—Where a current of electricity flows through a single wire, the amount of it that is changed into magnetism is very small, but if you wind quite a length of it into a coil, so that the turns are close together, the magnetic lines of force are concentrated, and this, naturally, gives a much stronger magnetic field. Further, the magnetic field is stronger inside the coil than it is outside of it, for the reason that the lines of force are closer to each other inside of it, since they spread out into the air on the outside of it.

The Jumping Spring.—This is a very simple little piece of apparatus that works by electro-magnetic induction. It is quite wonderful, in that it makes and breaks an electric circuit automatically, and you should, therefore, make one, for you will find it useful in a large number of experiments.

To make the jumping spring, get a piece of No. 16 bare copper wire, about six feet long, and wind it around a broomstick into a coil of about twenty turns. Cut out a block of hard wood one inch thick and three inches on the sides, and bore a hole half-way through

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it in the center. Make a support of a piece of stiff wire one-eighth inch thick, and nine inches long; bend one end over about two inches, and set the other end in a hole near one edge of the block.

Screw two binding posts near the other edge, then connect one of them with the support, and lead a wire

from the other one over to and into the hole, all of which is shown in *Fig. 51*. This done, pour enough

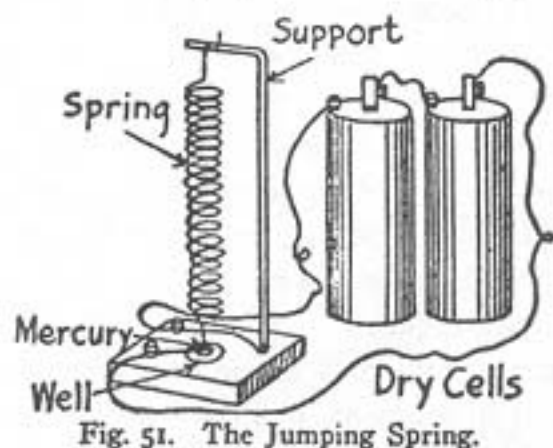


Fig. 51. The Jumping Spring.

mercury into the hole, or well, to half fill it, and adjust the spring so that its lower end just makes contact with it.

You are ready now to connect one of the binding posts of the jumping spring with one of the posts of the battery, and the other post of the spring with the other post of the battery. The instant this is done, the spring will contract, and this will pull the end that makes contact with the mercury up and out of it, when the circuit will be broken. Then the spring will expand to its normal length, when it will again make contact with the mercury, and the cycle of operations will be repeated. It is the magnetic attraction between the

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turns of wire that is set up by the electric current which causes the spring to contract, and when the current is cut off, gravity pulls it down to its normal length.

To Demonstrate the Inductive Effect.—You can demonstrate the magnetic effect that is produced by the electric current when it flows through the turns of the jumping spring, by simply holding your compass close to the turns of wire, as the spring makes and breaks the circuit. Every time the current flows through the spring, the needle will be attracted to it, and every time the current is broken, the needle will return to

its original position.

A Shocking Experiment.—Get two carbon rods—electric light carbons are good—and connect one of them to one of the binding posts of the jumping spring, and the other to the other binding post of it, as shown in *Fig. 52*. Let some friend of yours—or better, an enemy—hold the carbons, and then close the circuit of the jumping spring, and he will jump too!

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How to Make a Galvanometer.—A galvanometer is a little instrument, with which you can test the strength of batteries. To make one, cut out a strip of heavy cardboard one inch wide and seven inches long; bend it into a rectangular shape, as shown at *A* in *Fig. 53*, and glue the ends fast. Now

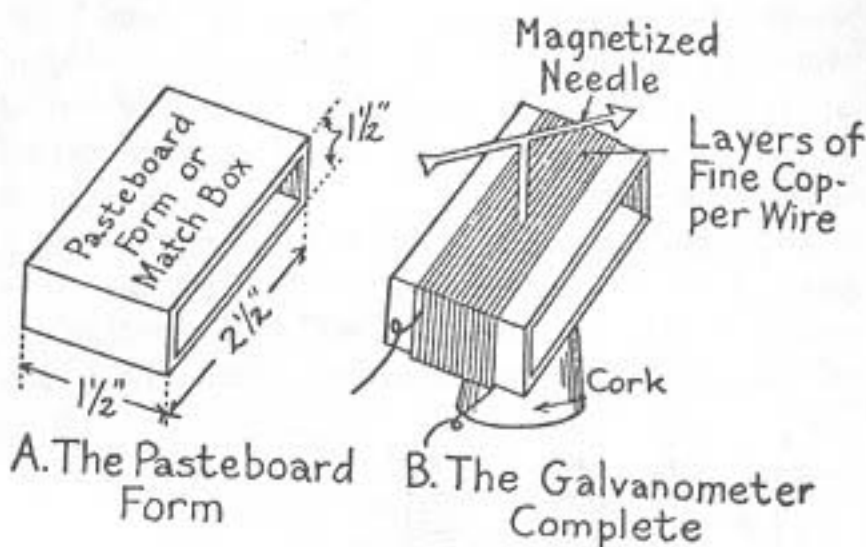


Fig. 53. How to Make a Galvanometer.

wind enough turns of No. 20 or 22 cotton-covered magnet wire¹ on the form lengthwise (See *B*), to make a layer three-quarters of an inch wide, and then brush it over with some shellac varnish, or melted paraffine. When this is dry, wind on another layer of wire, and then twist the ends together and give this layer a coat of shellac varnish, or paraffine. Now place your compass inside or outside of the coil of wire, when the galvanometer is ready to use.

¹ Magnet wire is a pure copper wire that is used for making magnets.

To test a cell or a battery to see whether it is de-

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livering current, set the galvanometer on a table, so that the turns of wire point north and south when the needle, since it also points north and south, will set parallel to them. This done, connect one of the binding posts of the battery with one of the posts of the galvanometer, and connect another length of wire to the other post of the battery.

Now touch the end of this wire to the free binding

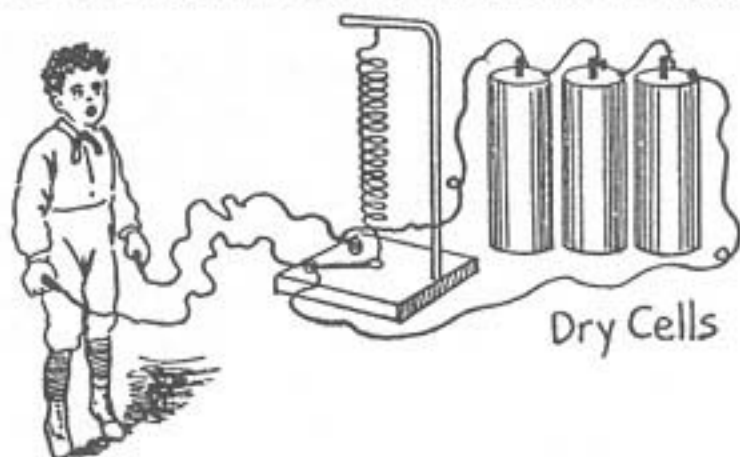


Fig. 52. A Shocking Experiment.

post of the galvanometer, when the compass needle will swing one way or the other, depending on the direction the current is flowing through the turns of wire. If you will make contact with the free end of the wire and the post of the galvanometer at timed intervals, the magnetic needle will spin around at a great rate, and you will have a little demonstration of an electric motor.

How to Make an Electro-Magnet.—You can make an electro-magnet in any one of several ways, and here are three of them: (1) The easiest and cheapest way is to get a staple, file off the pointed ends and then wind the legs full of No. 18 or 20 cotton covered magnet wire. There is a little trick in winding the magnet, and that is, when you have got one of them wound, you must bring the wire across to and begin winding it on the other leg in the opposite direction, as shown at *A* in *Fig. 54*. When you have wound three or four layers of wire on each leg, your magnet is ready for use.

(2) Another way is to have a blacksmith bend a piece of iron rod one-quarter or three-eighths of an inch in diameter, so that a U will be formed, which will be one and one-quarter inches between the centers

double cotton covered magnet wire on each leg, in the same way as described above, and then coat them with paraffine, or, better, give each layer a coat of shellac varnish, as you get them on.

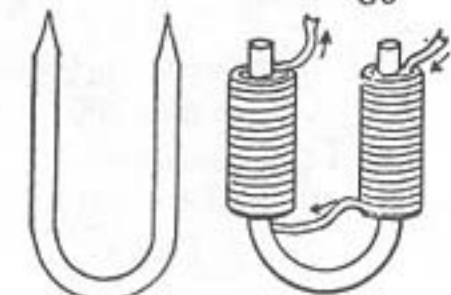
(3) A third and still better way to make an electro-magnet is to use a couple of machine screws, or bolts, if you want a large one, for the *cores*, as the legs are called, and a piece of flat, soft iron bar for the *yoke*, as that part of an electro-magnet is called which holds the two legs together. For a small electro-magnet suitable for making an electric bell, an annunciator, or a telegraph instrument, get two machine screws one-quarter of an inch in diameter, and one and three-quarters inches long, with nuts to fit them. Make the yoke of a piece of soft iron one-eighth inch thick, one-half inch wide, and one and three-quarters inches long. Drill, or have drilled, two quarter-inch holes in the yoke, three-quarters of an inch from each other, for the screws to pass through, and an eighth of an inch hole in the middle to screw it down to whatever you want to secure it.

Now, instead of winding the insulated wire directly on the screws, you make two spools, and this you do by cutting out four disks of heavy pasteboard for the cheeks, as the ends of the spools are called; make these disks one inch in diameter, and cut a hole in the center of each one five-sixteenths of an inch in diameter.

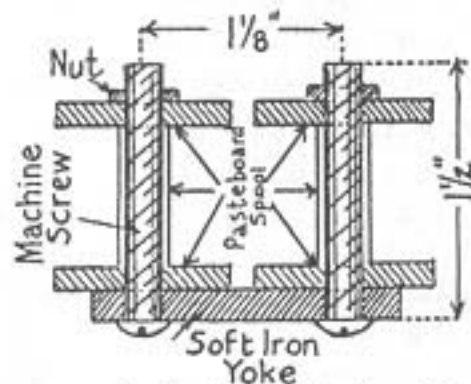
Next, make two stout paper tubes, the diameters of which are just large enough so that you can slip them over the screws, and have them each one inch long; this done, glue the pasteboard disks to the ends of the tube. Having made these, give them a couple of coats of shellac varnish and let them dry; then wind them full of No. 22 or 24 single cotton covered magnet wire, and in doing so be careful not to mar the insulation. After you have wound the spools full of wire, give them another coat of shellac and let them dry thoroughly.

To assemble the electro-magnet, begin by slipping the screws through the holes in the yoke, and then slip the spools of wire over the screws—and be sure that their windings are in opposite directions; finally, screw on the nuts, when your electro-magnet is complete and will look like *C*. All of the electro-magnets described above will be greatly improved, if you will *anneal* the cores first. This you can do by heating them in a fire until they are red hot, and then letting them cool very slowly in a bed of ashes.

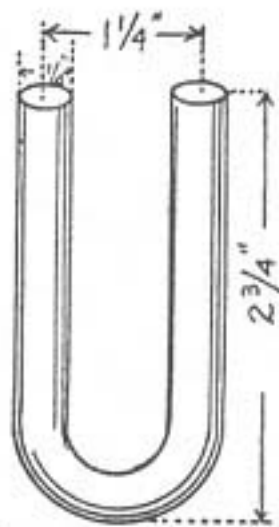
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A. An Electromagnet Made of a Staple



C. A Core Made of Machine Screws



B. A Bent Iron Core

Fig. 54. Some Easily Made Electro-Magnet Cores.

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of the poles, and two and three-quarters inches long from the ends of the poles to the bottom, as shown at *B*. Now wind four or more layers of No. 18 or 20

How to Make a Sucking Magnet.—The right name for a sucking magnet is *solenoid*. It consists simply of a spool of wire with a hole, called an *air core*, through it.

Experiments with a Solenoid.—A solenoid is a very handy piece of apparatus, as it can be used for a number of purposes. Among these are (1) it is an easy way to magnetize steel needles, watch springs and knife blades, very strongly. All you have to do is to drop them into the hole and switch on the current for a quarter or half a minute.

(2) Put one end of a soft, iron rod a little way in the hole of the solenoid, and turn on the current, when the spool will magnetize it and suck it into it.

(3) Place a thin sheet of cardboard, or mica, on the end of the solenoid over the hole, and sift some iron filings on it. Then connect the solenoid with a couple of dry cells, when you will find the hole of the solenoid is strongly magnetic.

(4) To make an *electro-magnet gun* of your solenoid, slip a brass tube into the hole and then lay it down with one end on a pencil, as shown in Fig. 55.

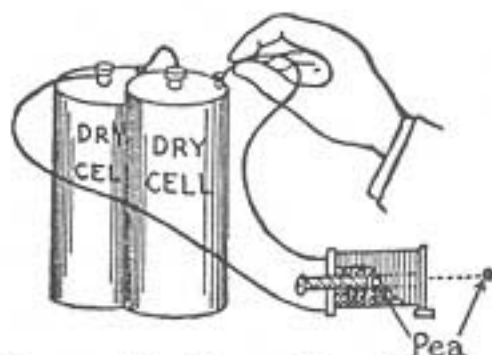


Fig. 55. The Electro-Magnetic Gun.

Now slip one end of an annealed screw into the lower end of the hole, and drop a dried pea into the other and upper end of the hole. Connect one of the wires of the solenoid with one of the posts of a battery of three or four cells. Now touch the other wire of the solenoid to the other post of the battery, when the iron screw will be pulled smartly forward, and the pea in front of it will be propelled with some little force from the mouth of the tube.

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VI

ELECTRIC BELLS, ANNUNCIATORS AND BURGLAR ALARMS

With a dry cell or two and an electro-magnet, such as I have described in the foregoing chapter, you can

make not only many pleasing experiments but several useful pieces of apparatus, and among these are electric bells, annunciators, and burglar alarms. You can, of course, buy any of these devices all ready to install, but there is a lot of satisfaction to be got out of making them with your own hands, beside the working knowledge that will accrue to you from doing so.

How to Make an Electric Bell.—An electric bell consists of (1) an electro-magnet, (2) a bell, or gong, as it is called, (3) a flat vibrating spring, to which there is riveted (4) a contact spring; on one end of the vibrating spring there is fixed (5) a soft iron armature, and to the end of this is secured (6) a wire with a metal ball, or hammer, and, finally, there is (7) an adjustable screw contact point.

To assemble the bell, get a board about three inches wide and five and one-half inches long, and on this mount your electro-magnet. Get a strip of spring brass three-eighths of an inch wide and two and one-half inches long, and drill a hole through both ends. Drill another one inch from one end, and still another three-quarters of an inch from the other end, as shown

at A in Fig. 56. Next, drill a hole in a piece of spring brass, as shown at B, and also drill two holes in a piece of soft iron three-thirty-seconds of an inch thick, three-eighths of an inch wide, and one and one-eighth inches long. (See C) and rivet these and the brass spring together.

This done, solder a piece of brass rod one-quarter of an inch in diameter and three-eighths of an inch long,

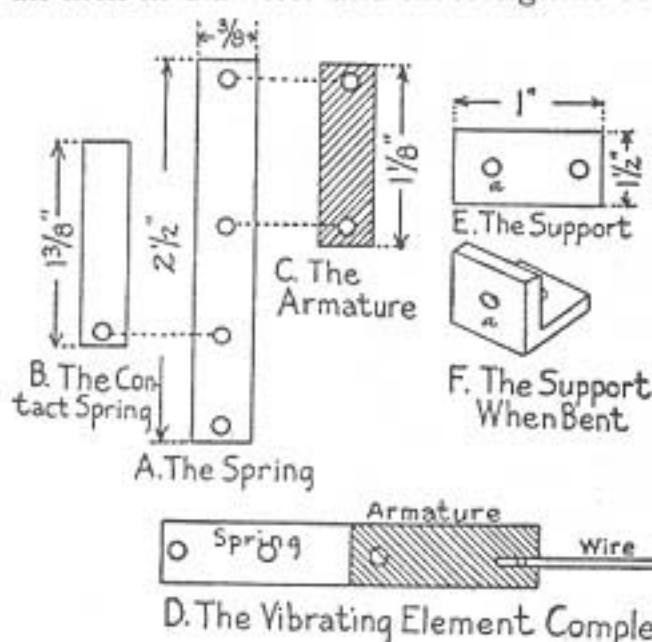


Fig. 56. The Parts of an Electric Bell.

to one end of a stiff brass wire one and three-eighths inches long, and solder the other end of this to the end of the brass spring on which the armature is riveted, as

shown at *D*; screw the end of this to the end of a block of wood, so that the armature will be parallel with and about one-eighth inch from the ends of the magnet. Then mount the gong on the board, so that the hammer will come within one-sixteenth inch of it.

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Next, and last, make the adjusting screw contact, and this consists of two parts, namely, the support and the screw. To make the support, get a piece of brass one-sixteenth or three-thirty-seconds of an inch thick, one-half an inch wide, and one inch long, and drill a hole in each end of it, as shown at *E*; tap out the hole marked *A*, so that a 6-32 machine screw will fit in it, then sharpen a 6-32 screw, screw it in and put a nut on it. Now screw the support in a vise and bend it over, as at *F*; this done, screw it to the base one-

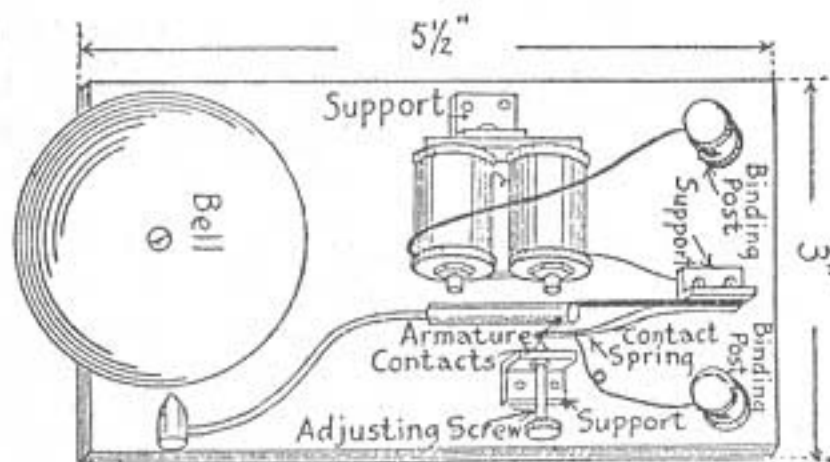


Fig. 57. The Electric Bell Complete.

quarter inch from the brass spring of the vibrator, and adjust the screw until the point of it just makes contact with the surface of the spring. Then mount two binding posts on the base, and you are ready to wire up the bell.

To do this, begin by connecting the right hand post with one of the ends of the coil of the electro-magnet, and the other end of this with the fixed end of the vibrator spring, and then connect the adjusting screw standard to the other binding post, all of which is

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shown in *Fig. 57*. To ring the bell you have, of course, to connect it with a battery, and if you want to use it as a door-bell or a call-bell, you must connect it with a push button, which is a simple spring contact.

How an Electric Bell Works.—When you push the button, the spring to which it is fastened makes contact with another piece of metal, and this closes the circuit; the current from the battery then flows through the coils of the electro-magnet and so energizes it.

The instant the cores are magnetized, the poles pull

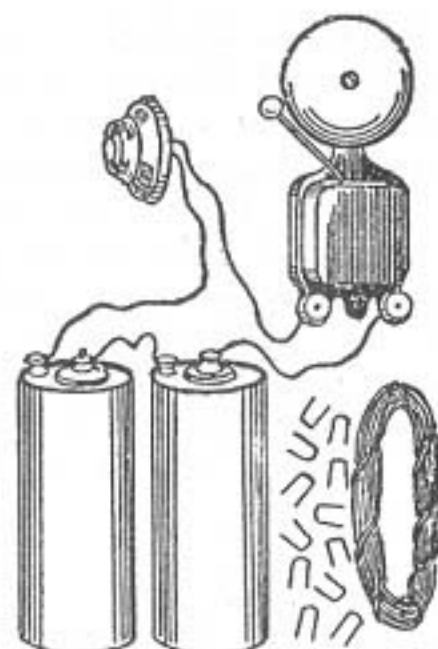


Fig. 58. An Electric Bell Outfit Ready to Put Up.

the armature toward them, when the hammer strikes the gong; at the same time the contact between the point of the adjusting screw and the spring is broken, and, in consequence, the current stops flowing and the electro-magnet is de-energized. The armature then

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flies back by virtue of its own spring and contact is again made with the adjusting screw point, when the circuit is once more completed. In this way, the cycle of operations is constantly repeated as long as the push button makes contact.

To get the best results, you must have the armature exactly the right distance from the poles of the magnet, and you can get it so by a little experimenting. The pressure of the adjusting screw on the spring must also be just right, and this critical point you can find by trying it out. You can buy an electric bell ready for use for a dollar, or less, while a push button costs from ten cents on up, according to the finish. An electric bell outfit is shown in *Fig. 58*.

How to Wire Up Two or More Electric Bells.—Where two, or more, electric bells are to be connected with one, or more push buttons, you must wire them up in *parallel*, as shown in *Fig. 59*. This way of con-

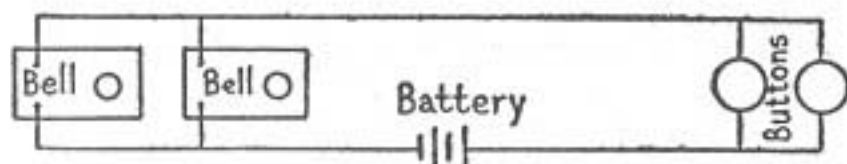


Fig. 59. Electric Bells and Push Buttons Connected in Parallel.

necting them up not only saves wire and the work of wiring, but a single battery can be used to ring as many bells as you like, depending upon the size or capacity of the battery used.

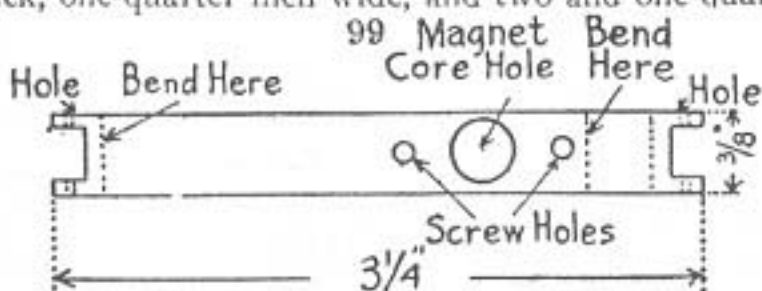
How to Make an Annunciator.—An annunciator is an apparatus consisting of two or more numbers, or names, either or any one of which can be dropped from a concealed position into one where it can be seen when

a distant button is pushed. It is used in homes, hotels and elevators, to indicate to the one in charge which room or which floor the call is made from. Usually, an electric bell is connected with and forms a part of the annunciator, so that when a number, or a name, is visibly indicated, the attention of the one in charge is audibly called to it.

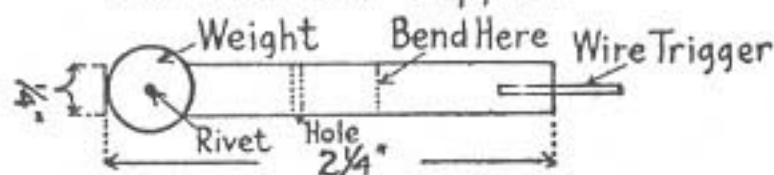
The annunciator which I shall tell you how to make, is the regulation gravity drop type. That is, an electro-magnet releases a lever which carries the number, and it falls by its own weight from a concealed to a visible position. When this takes place, it must again be set by pushing up the lever by hand, when it will catch on the trigger armature. I will tell you how to make one drop, as each separate electro-magnetic device is called, and then you can make as many of them as you want to, and mount them all in one housing.

Begin by making an electro-magnet, as I have explained in a previous chapter, but in this case you only need one core and one spool. Get a screw one-quarter inch in diameter and one and one-half inches long, and wind the spool full of No. 20 or 22, enamelled or cotton covered magnet wire. For the support, which is shown at *A* in *Fig. 60*, get a strip of brass one-sixteenth inch thick, three-eighths of an inch wide, and three and one-half inches long, and saw, or file, out the ends three-sixteenths of an inch deep. Also drill the holes, as shown at *A*, and in the cross-sectional drawing at *D*.

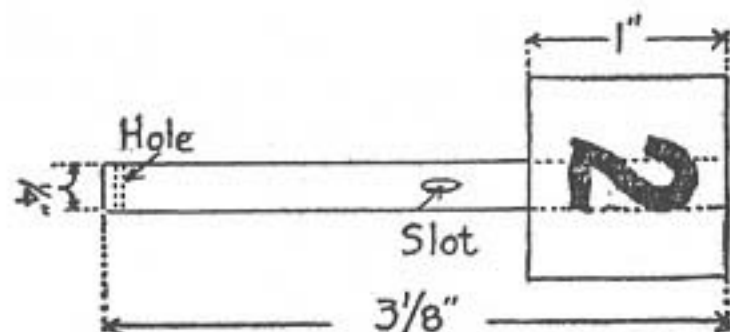
The next thing to do is to make the iron armature, and this consists of a strip of iron one-sixteenth inch thick, one-quarter inch wide, and two and one-quarter



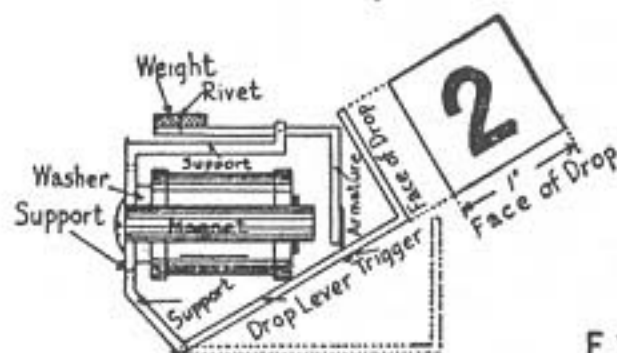
A. The Brass Support



B. The Iron Armature



C. The Drop Lever



D. Cross Section of an Annunciator Drop



E. The Drop Complete

Fig. 60. Parts of an Annunciator.

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inches long, as shown at *B*. Drill a hole through it, rivet a piece of one-eighth inch thick iron to one end for the weight, solder a piece of wire to the other end (See *B*), and bend it to the shape shown at *D*. Now make the drop lever of a strip of brass one-sixteenth inch thick, one-quarter inch wide, and three and one-eighth inches long; drill a hole through it at one end, and fasten a one inch piece of cardboard to the other end, on which is printed the number, or name, you want, as shown at *C*, and bend it as shown at *D*.

You are now ready to assemble the drop, and this you do by putting the screw of the magnet core through the hole in the support, and slip a thick iron washer over it. Then slip the spool of wire over the core and secure it there with a nut. This done, pivot the armature lever to the top end of the brass support and pivot the drop lever to the lower end of the support, so that the wire trigger of the armature will pass through the slot, as at *D*.



Fig. 61. A Four Drop Annunciator.

Finally, bend the wire on the end of the armature, so that when you raise the drop lever it will catch and stay in place, but when you push the armature lever

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toward the pole of the magnet it will fall to the position shown by the dotted lines at *D*. When you have made as many of these drops as you need, screw them to the back of a wooden case, in the front of which is a sheet of glass. The upper part of this must be painted black, so that when the number is up it will be hidden. A four-number annunciator is shown in *Fig. 61*.

How to Connect Up the Annunciator.—For an annunciator with two or more drops, and with as many push buttons, and to have a bell ring at the same time they operate, you must connect them up, as shown in the wiring diagram in *Fig. 62*. Button *A* rings bell only; button *B* rings bell and drops call No. 1; button *C* rings bell and drops call No. 2.

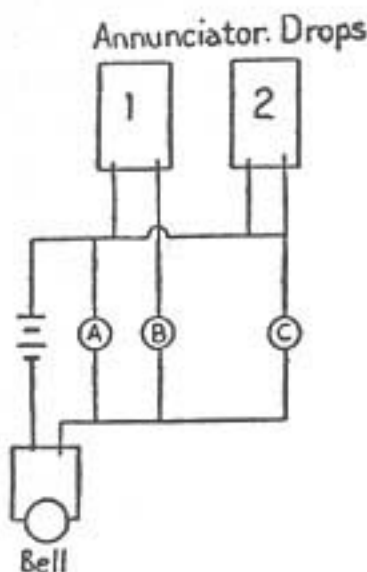


Fig. 62. How an Annunciator is Wired Up.

How to Rig Up a Simple Burglar Alarm.—A simple burglar alarm is easy to make and install, and likewise not very difficult for a burglar to circumvent,

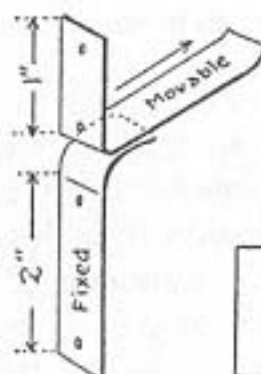
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but it will serve very well under certain conditions. For this alarm all you need is an electric bell, a dry cell or two, and a couple of strips of spring brass for the contacts, as shown at *A* in *Fig. 63*.

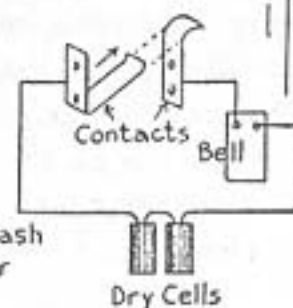
Screw one of the contacts to the inside of the frame of the window and the other one to the window-sash, as shown at *B*. Then connect the bell and the battery, and your alarm is set. Now, when the burglar jimmies the window and begins to raise it, the strips of brass will make contact with each other and the bell will ring.

If it is a door you want to protect, then screw one of the contacts to the upper part of the frame of the

Fasten to Lower Sash
or Frame of Door



Fasten to Upper Sash
or Frame of Door



A: Spring Contacts *B:* Wiring Diagram

Fig. 63. A Simple Burglar or Door Alarm.

door and the other contact to the top of the door. Now, as the door is opened the strips of brass make

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contact and the bell rings. When this happens you can do one of three things, to wit, (1) shoot the burglar, (2) 'phone for the police, or (3) hide under the bed.

How to Rig Up a Better Burglar Alarm.—It is better to buy a burglar alarm trap, as this particular little piece of apparatus is called, than it is to make it, unless you are something of a mechanic, for if it is not carefully made it will not work well, and a burglar alarm that won't work when it ought to is worse than none at all.

The burglar alarm trap which is shown at *A* in *Fig. 64*, costs only about \$1.50, but you will need one for

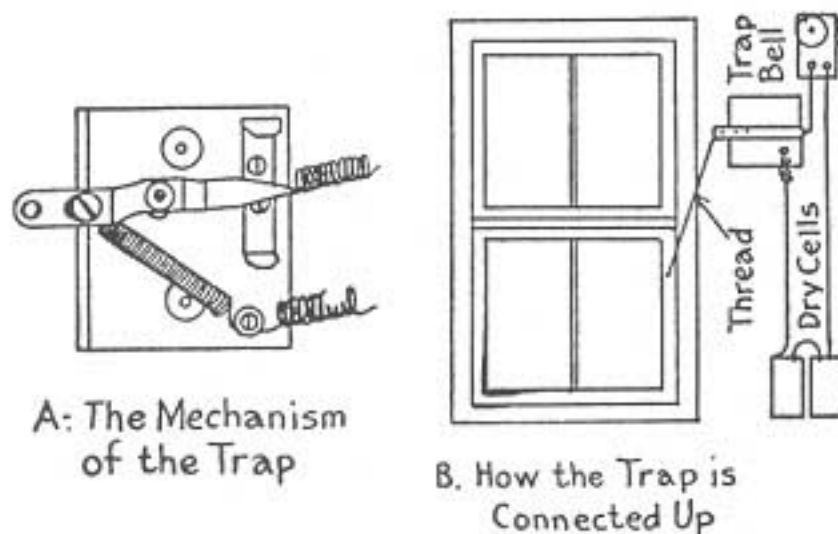


Fig. 64. The Burglar Alarm Trap.

each door and window you want to protect. It consists of a fixed pair of contact points screwed to a base and a contact lever, which is pivoted to the latter. Now, when the lever is pulled either way, the free end of it makes contact with the fixed points. A spiral

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spring is secured to the lower end of the contact lever, while a thread is tied to the extreme lower end of it.

To install the trap, you screw it close to the window or door you want to protect and fasten the free end of the thread to a window-shade or window-sash, to the transom, or a door, or stretch it across a room, or a hall. Now if Mr. Burglar should do anything that interferes with the tension of the thread, it will either pull the lever into contact or else make the spring pull it into contact, and so close the circuit, when the bell will ring. It is obvious that the trap will also serve as a very efficient fire alarm if the heat becomes great enough to set fire to the thread. The way it is connected to the battery and bell is shown at B.

How to Install an Open Circuit Burglar Alarm.—The first thing a burglar does when he finds an alarm has been put in is to cut the wires, if he can possibly do so when, of course, the circuit is broken and the system is put out of commission. Now, suppose you have a garage some distance from your house, that you want to protect and there is no one sleeping in it; the thing to do then is to install an open circuit alarm.

To do this, you run a pair of wires from the house to the garage first, and you don't care if the burglar knows it. Then you put a pair of spring contacts on the door, like those described for a simple burglar alarm, so that when the latter is opened ever so little the contacts will break apart; likewise fit the windows with contacts, so that if any one of them is opened they will also break the circuit.

Now connect one of the ends of the line wire with one of the first pairs of contacts, and connect the other of this first pair to one of the second pair, and so on, until all of the pairs of contact points are connected in series, as shown in the diagram, *Fig. 65*. Connect

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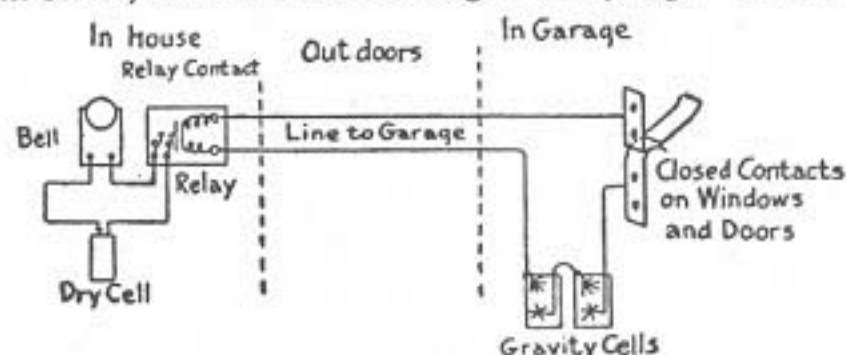


Fig. 65. An Open Circuit Burglar Alarm.

the last contact of the last pair with one of the posts of a battery of two gravity cells, such as are used for telegraph work, for a current must flow through the

circuit all of the time and, hence, any other kind of a battery would soon run down; then connect the other post of the battery with the end of the other live wire. This is all of the equipment that is needed in the garage.

The apparatus required for the house consists of an electric bell, a pony relay, which you will find described in the next chapter, and a dry cell or two. Set these in any convenient place and connect the terminal wires of the electro-magnet of the relay with the ends of the live wires, that is, the wires which run to the garage. Then connect one of the contact points of the relay with one of the posts of the bell, the other post of the bell with one of the posts of the battery, and the other post of the battery with the contact point of the relay. (See *Fig. 65*.)

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How the Open Circuit Burglar Alarm Works.—It must be clear now that as long as the entire line circuit is intact, that is, not broken at any point, the current from the gravity battery in the garage will constantly flow through the door and window contacts and through the coils of the electro-magnet of the relay in the house.

This keeps the electro-magnet of the latter energized all of the time, and this, in turn, attracts the armature to it and holds the contact points apart. As the latter are included in the bell circuit—in the same way as the push button is—the bell circuit is open. But the moment that the garage door or a window is opened, or the burglar cuts the live wires, the current from the gravity battery ceases to flow and the electro-magnet of the relay is de-energized, when the retractile spring of the relay armature pulls the latter back and the points make contact. This closes the local circuit, when the current from the dry cell rings the bell.

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VII

THE TELEGRAPH AND TELEPHONE

The Morse Telegraph.—The Morse telegraph, which is the ordinary wire telegraph now in use, is so called because it was invented, in 1842, by Samuel F. B. Morse. After having made an electric bell, you will have no trouble in making a Morse telegraph set, that is, a telegraph set in which the sending apparatus is connected with a wire to the receiving apparatus. In its simplest form a Morse telegraph set consists of (1) a *key* for breaking up the current into dots and dashes, (2) a *battery* for generating the electric cur-

rent, and (3) a *sounder* for audibly indicating the dots and dashes.

How to Make a Simple Telegraph Set.—For merely demonstrating the principles of the Morse telegraph, you can make and use the key described in Chapter IV under the caption of "How to Make a Flash-light Telegraph." For the battery you can use a couple of dry cells, and the sounder you can make as follows:

Get a piece of wood for the base one-half inch thick, two and one-half inches wide, and three and three-quarters inches long, and bore six one-eighth inch holes through it and two three-eighths of an inch holes half-way through it, as shown at *A* in *Fig. 66*. Next, screw two pieces of hard wood one-half inch square and one and one-quarter and one and one-half inches in length respectively to the base, as shown at *B*, for the supports.

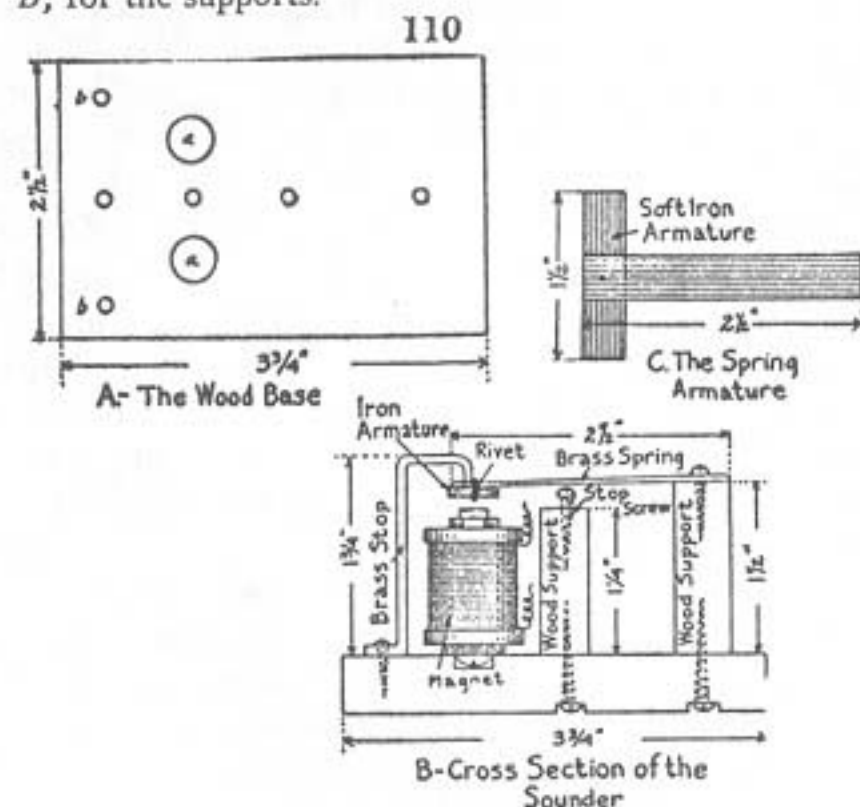


Fig. 66. A Simple Telegraph Sounder.

In the top of the shorter support put a small wood screw, called a stop-screw for the reason that it stops the movement of the armature before it makes actual contact with the end of the polar projection of the electro-magnet. Cut a strip of spring brass three-eighths of an inch wide and two and one-half inches long, and rivet, or solder, it to a piece of very soft iron one-sixteenth, or three-thirty-seconds of an inch thick, three-eighths of an inch wide, and one and one-half inches long, to form a T, as shown at *C*. This done, screw the free end of the brass spring down to the top of the longer of the wood supports, as shown

at *B*.

The next step is to screw the yoke of the electro-magnet¹ to the base-board and the purpose of the two larger holes *AA* is to allow the heads of the screws to sink below the surface of the base, when the yoke will rest firmly on it. Now take a piece of brass about one-sixteenth inch thick, three-eighths of an inch wide, and three and one-quarter inches long, and bend it, as shown at *B*; then screw it down to the base in front of the electro-magnet, so that its upper end will rest over the middle of the armature. Finally, screw a binding post to each corner of the base *bb*, and connect the ends of the wire of the electro-magnet to them, when your sounder is complete.

¹ Directions for making this electro-magnet are explained in Chapter V, Paragraph 3.

How to Connect Up the Instruments.—To wire up the key, the battery and the sounder, all you have to do is to connect one of the binding posts of the key with one of the binding posts of the battery, the

other binding post of this with one of the posts of the sounder, and the other post of this to the remaining post of the key, all of which is shown in the wiring diagram, *Fig. 67*.

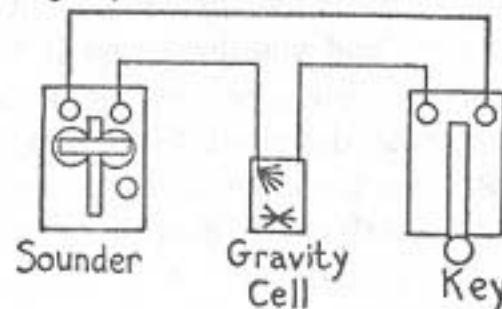


Fig. 67. How the Key, Sounder and Battery Are Connected Up.

Now, when you press down on the key, it closes the circuit and the current from the battery energizes the electro-magnet of the sounder; this pulls down the armature, and as the spring, which is fixed to it, strikes the stop-screw, it makes a sharp click. When you release the pressure on the key, it breaks the circuit and the electro-magnet is demagnetized, when, of course, the armature flies up by its own elasticity; as it strikes the brass stop it makes another sharp click, which is different from the sound of the other, and it is the time that elapses between these two sounds that enables an operator to tell whether the received signal is a *dot* or a *dash*.

How to Learn to Send and Receive in the Morse Code.—If it is your ambition to become a Morse telegraph operator—that is, to work for the railroad, Postal or Western Union, then you want to learn the

regular Morse Code. The letters of the alphabet of this code, like modifications of it that have since been devised, consist of dots and dashes.

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To send a *dot*, press the key down until it makes contact and quickly let it up again; the result is that the spring, or lever, of the sounder makes two clicks very close together. To send a *dash*, hold the key down so that it makes and remains in contact three times as long as for a dot, while an extra *long dash* is equal in length to seven dots.

THE MORSE ALPHABETIC CODE

A	B	C	D	E	F
G	H	I	J	K	L
M	N	O	P	Q	R
S	T	U	V	W	X
Y	Z	A	S		
NUMERALS					
1	2	3	4		
5	6	7	8		
9	0				

Punctuation

Comma, .	Exclamation, !
Semicolon, ;	Parenthesis, ()
Colon, :	Brackets, []
Period, .	Dollar mark, \$
Interrogation, ?	Dash, -
Quotation, " "	Hyphen, -
Paragraph, ¶	Underline, <u> </u>

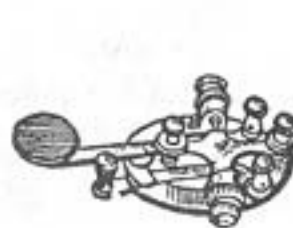
How to Put Up a Regular Wire Telegraph.—By a regular wire telegraph set, I mean one that you and your pal can send messages with in both directions. To do this, all you need is (1) a couple of regular telegraph keys, (2) one gravity battery, (3) a couple of regular sounders, and (4) enough wire to connect the stations together.

The Morse Key.—The difference between a

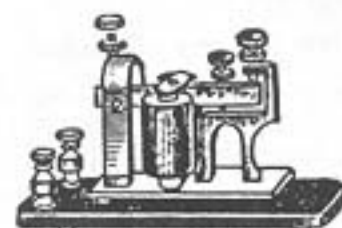
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regular Morse Key and the simple strap key which I have previously described, is that the former has a switch lever on it, so that when you are not sending the circuit can be kept closed; the only time you leave the circuit open is when you are sending. The switch lever sets on the right hand side of the contact lever, where it is within easy reach of your fingers. A regular Morse Key is shown at A in Fig. 68.

The Gravity Battery.—For a short line one or two gravity cells will be enough to work the instruments. You will remember I told you in Chapter III that a gravity battery is necessary for working a telegraph line because it is a closed circuit battery, that is,



A- A Regular Key



B- A Regular Sounder

Fig. 68. A Morse Key and Sounder.

it keeps in good working order just as long as it is generating a current and it gets out of order very quickly when the circuit is left open. For this reason, it is admirably adapted for telegraph work. It is shown in Fig. 32 in Chapter III.

The Sounder.—This piece of apparatus is constructed on the same principle as the simple one described in the beginning of this chapter, but since it is for actual use, it is made better and of heavier materials and designed so that the throw of the lever can be accurately adjusted. The electro-magnets of all

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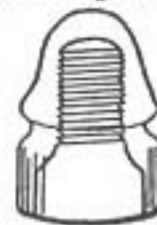
sounders are wound to about four ohms resistance. A regulation Morse sender is shown at B.

How to Put Up the Line.—Where you and your pal are going to have a private wire, that is, one all your own, you will, of course, need two sets of instruments, but only one battery, which may be placed at either end of the line. Moreover, you need only one wire to connect the instruments together, as you can use the earth to complete the return circuit.

You can use any kind of wire for the line, but regular No. 14 galvanized telegraph wire is the strongest and cheapest, if you have to buy it. It takes about one hundred pounds of this wire to the mile, and the price of it is about ten cents a pound. In stringing



A. A Porcelain Insulator



B. A Glass Insulator

Line Wire → Insulator



C. Wire on the Insulator



D. A Wire Splice

Fig. 69. For the Line Wire.

the wire between the two stations, you must be care-

ful that it does not touch trees or other obstacles; and to keep it from coming in contact with the poles or buildings which support it, you must use either porcelain or glass insulators, as shown at *A* and *B* in *Fig.* 69.

Where the line is short, you can use small knob porcelain insulators, and these can be screwed directly to whatever is to support them. Where the line is a long one, it must be better insulated, and glass petticoat insulators should be used; these have to be screwed to wood brackets, which are, in turn, fastened to the poles or other supports. The way the wire is secured to the insulators is shown at *C*. Where the ends of wires are to be joined together, they should be scraped clean, twisted together, as shown at *D*, and then soldered.

How to Make the Ground.—It is evident that by using the earth instead of another wire to complete

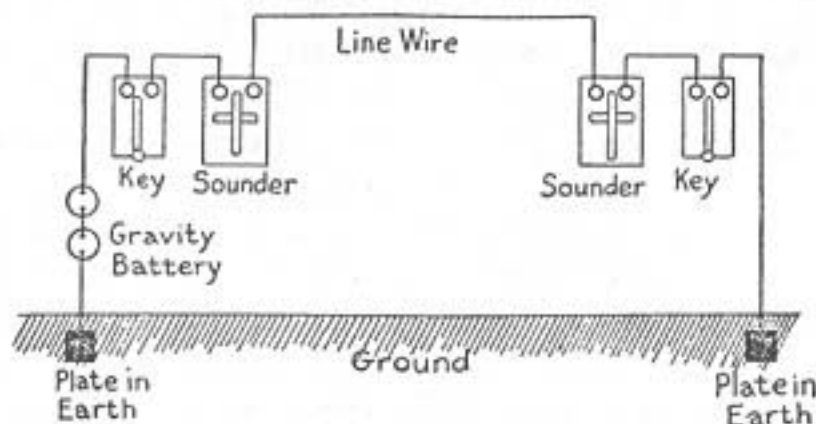
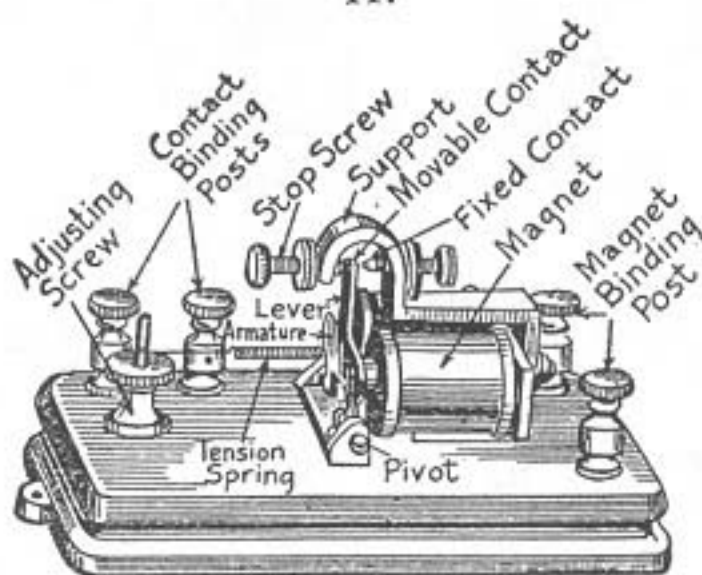
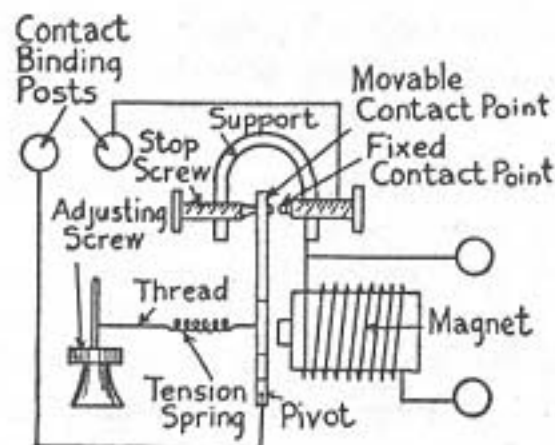


Fig. 70. How a Simple Telegraph Set is Connected Up.

the circuit, a great saving is effected, not only in cost of materials but in work as well. To connect the instruments with the earth, you can, if the line is a short one, clamp, or solder, the wire to a water or a gas pipe, but if the line is a long one, it is better to



A-A Standard Pony Relay



B- Wiring Diagram, Standard Pony Relay

Fig. 71. A Relay for a Burglar Alarm or a Long Line Telegraph.

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use a sheet of zinc or copper that is buried in moist earth.

How to Connect Up the Instruments.—For a *short line system*, that is, where two keys and two sounders and a battery are used, you can connect them together and to the line wire and the grounds, as shown in the diagram, *Fig. 70*. Since the instruments and the battery are connected in *series*, you can place the battery anywhere you want to in the circuit.

Where a *long line system* is run, a *relay* must be used, as it is much more sensitive than a sounder. Also, where there are three or more stations on the line, a relay must be used at every station. A relay is an instrument that has an electro-magnet wound from fifty to two hundred and fifty ohms resistance; it is fitted with a delicately poised armature that works against a contact point; it takes a very small current to operate the armature, and as this is worked by the main line circuit, it opens and closes a second circuit, called the *local circuit*, in which another battery and sounder are connected. A standard pony relay is shown at *A* in *Fig. 71*, and a wiring diagram of it at *B*, while the way it is connected in the line is shown in *Fig. 72*.

The Bell Telephone.—The Bell telephone, which is the ordinary wire telephone, is so called because it was invented, in 1876, by Alexander Graham Bell. The Bell telephone in its simplest form consists of two like pieces of apparatus, which we now call telephone receivers. Thus, in the beginning of telephony (pronounced *tel-ef'-o-ny*) the transmitter and the receiver was one and the same instrument, that is to

say, you placed one of them to your ear when you wanted to hear what the fellow at the other end of

the line was saying, and you spoke into another one when you wanted him to hear what you had to say.

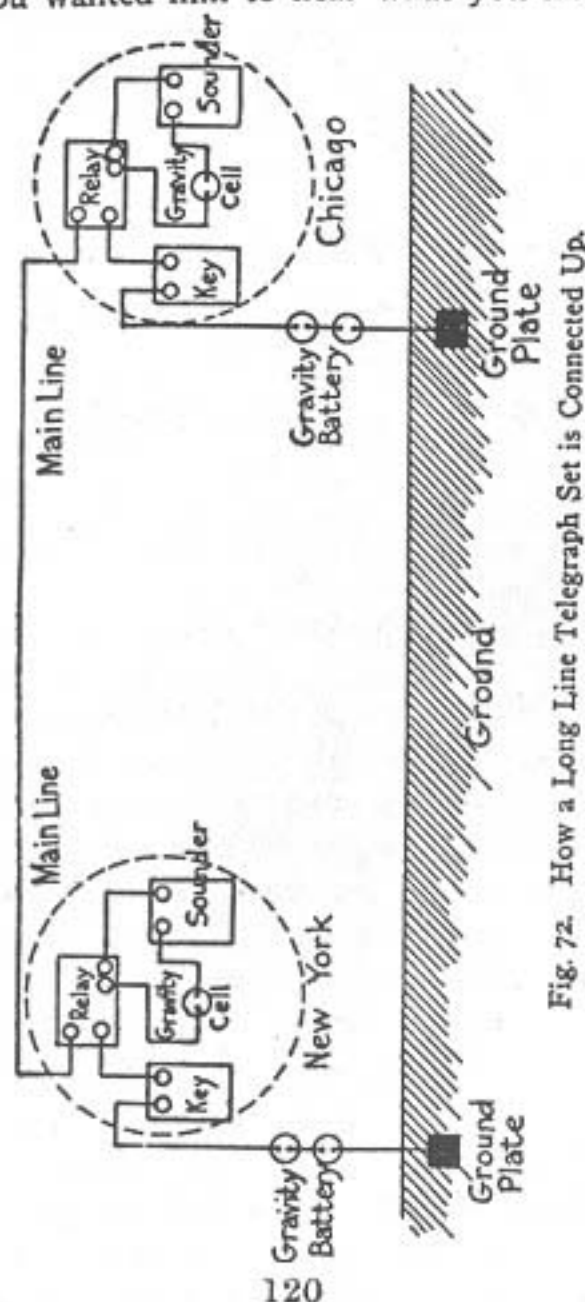
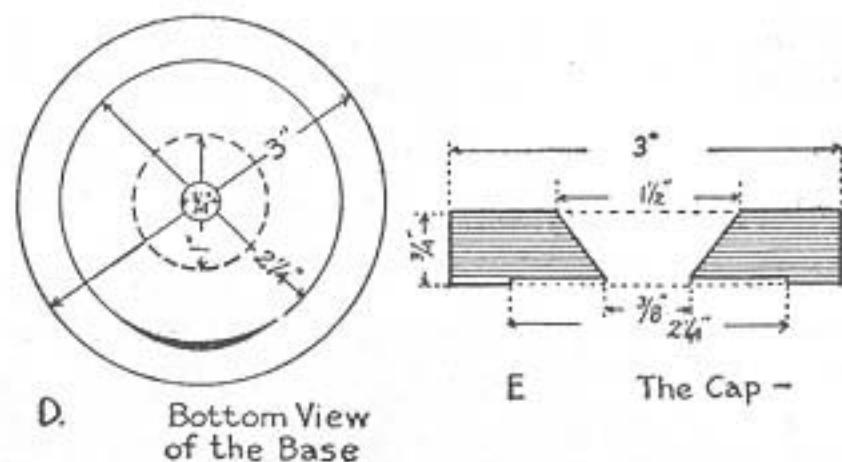
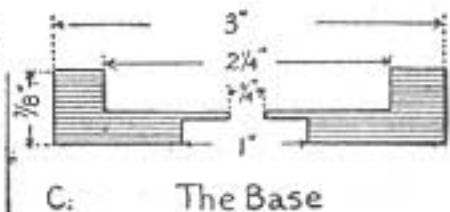
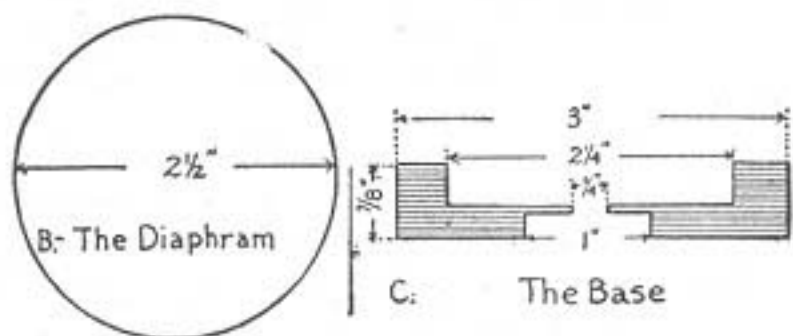


Fig. 72. How a Long Line Telegraph Set is Connected Up.



D. Bottom View of the Base

E. The Cap -

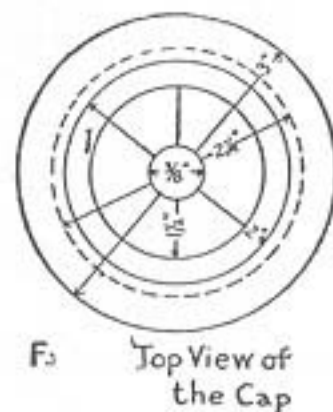
(A-E) Fig. 73. The Parts of a Home-Made Telephone Receiver.

easy and cheap way to make an experimental telephone receiver, which you can also use as a transmitter. Telephone receivers are so cheap, though, that

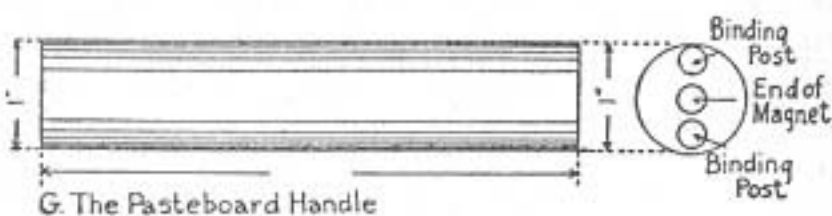
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it is hardly worth your while to make one, except for the experience and knowledge you will get out of it, in which case proceed as follows:

Begin by getting a permanent steel bar magnet three-eighths of an inch in diameter and six inches



F. Top View of the Cap



G. The Pasteboard Handle



H. The Pasteboard Spool

(F-H) Fig. 73. The Parts of a Home-Made Telephone Receiver.

long, as shown at A in Fig. 73, and an iron diaphragm, which is a thin japanned iron disk, two and one-half inches in diameter, as at B, a pair of small binding posts, and one-half ounce of No. 36, 38 or 40, enamelled or single silk-covered magnet wire, and these are the only materials you have to buy:

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Later on, when the art of telephony had developed a little further, a separate transmitter was invented, and the original Bell device was used only as a receiver.

How to Make a Telephone Receiver.—Here is an

First, make the base of the receiver, which you can

easily do by cutting out fourteen disks of one-sixteenth inch thick pasteboard, and cut a two and one-quarter-inch hole in the center of eight of them; a one-quarter-inch hole in one of them, and a one-inch hole in the remaining five. This done, glue all of the disks together, as at *C* which shows a cross-section of them, that is, as if the base were cut right through the middle. A top view of the base is shown at *D*, the dotted circle representing the one-inch hole in the bottom of it, which cannot, of course, be seen when looking at the top.

Next, make the cap, and this you do by cutting out twelve more one-sixteenth-inch thick pasteboard disks. Cut a hole in one of them one and one-half inches in diameter, and cut a hole in each one of eleven of them, so that when you glue them together a cone-shaped mouthpiece will result, of which the outside and largest one is one and one-half inches in diameter, and the smallest one is three-eighths of an inch in diameter. This done, cut a two and one-quarter-inch hole out of the twelfth disk and glue this to the bottom of the cap, as shown at *E*. A top view of the cap is shown at *F*.

Now get or make a pasteboard tube one inch in diameter and five inches long, and make two pasteboard disks about one-quarter inch thick, which fit snugly into the ends of the tube. Cut a three-eighths of an inch hole in the center of both disks for the magnet to pass through, and all of which is shown at *G*. Glue the disks into the ends of the tube and then glue one end of the latter into the hole in the base.

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The next step is to make a pasteboard spool with a hollow spindle seven-sixteenths of an inch in diameter, and with cheeks one inch in diameter, as shown at *H*. When this is dry, wind it full of the fine wire, then slip it over one end of the magnet, so that the end of the latter will project above the cheek to within one-sixteenth of an inch of the top edge of the base.

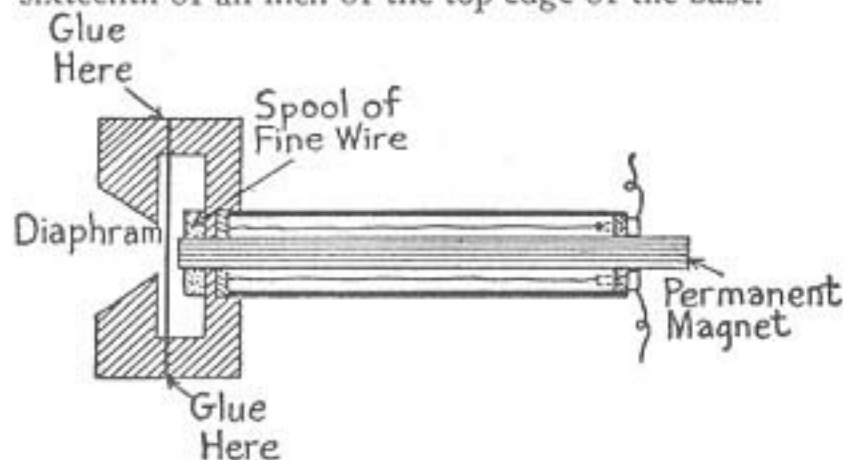


Fig. 74. Cross Section of the Telephone Receiver.

Now push the magnet through the small hole in the base and on through those of the tube. Screw the binding posts to the bottom of the base, as shown at *G*, and connect the wires of the magnet coil to them. Finally, place the diaphragm on top of the base and then glue the cap securely to the latter, when the diaphragm will be held securely in position and your telephone is ready for further orders. It is shown in cross-section in *Fig. 74*.

How to Put Up a Simple Telephone Line.—With a pair of these telephone receivers, or, better, with a pair that you buy ready to use (See *Fig. 75*), you can put up a line over which you can talk both

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ways for half a mile or so. To do this, you must have a complete metallic circuit, that is, a pair of wires, for where the earth is used as a return circuit there is so much noise, due to currents flowing through the earth,



Fig. 75. A Bought Telephone Receiver.

it makes it difficult to hear plainly. To get the best results use copper wire No. 16 or 18. This should be strung on porcelain or glass insulators, and all that is necessary is to connect the two receivers together, as shown in *Fig. 76*, as a battery is not needed.

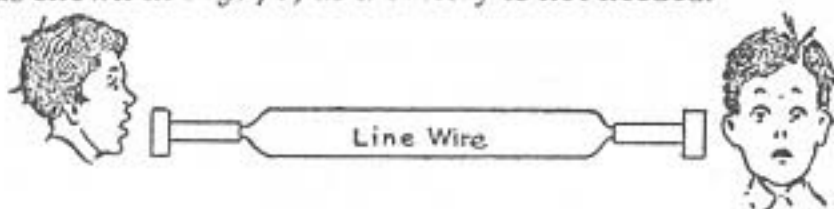


Fig. 76. A Simple Telephone Outfit.

How the Telephone Works.—When you use a telephone receiver as a transmitter and talk into it, the sound waves set up by your voice make the iron diaphragm vibrate to and fro, and this changes the magnetic strength of the permanent bar magnet. Every variation in the strength of the latter sets up a

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current in the coil of wire on it, and this travels on over to the other telephone.

When these currents of varying strength reach the other telephone, it acts as a receiver, and as they flow through the coil they change the strength of its magnet, which, in turn, attracts the diaphragm and makes

it vibrate to and fro. This sets up waves in the air, or *sound waves*, as they are called, and the ear of the listener hears them, since they are just the same as those sent out by the voice of the speaker.

Some Experiments With a Telephone Receiver.—There are a number of amazing experiments that you can make with a telephone receiver, a couple of dry cells, and some simple apparatus that you can easily rig up. One of these pieces of apparatus is called a *microphone*, and it was invented by Hughes.

How to Make a Microphone.—A microphone is

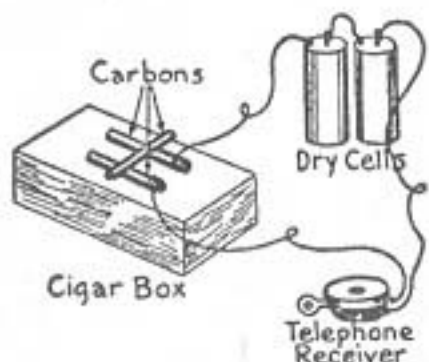


Fig. 77. How to Make and Connect Up the Microphone.

a very wonderful device, as it magnifies sounds, just as a microscope magnifies images of objects; moreover, it is simplicity itself. To make a microphone, get three pieces of electric light carbon about two and one-half inches long.

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Twist a piece of copper wire about two feet in length around the ends of two of them, and then connect one of them to one of the posts of a battery, the other one to one of the posts of the telephone receiver, and connect the other telephone post to the other battery post. Lay these two carbons on an empty cigar box, so that they are parallel and about an inch apart, and lay the free carbon across them, as shown in Fig. 77, when your microphone is complete and ready for work.

To Magnify the Ticks of a Watch.—Lay a cheap watch (because this kind has a loud tick) on top of an empty cigar box and close to the microphone, as in Fig. 78, and hold the receiver close to your ear. The

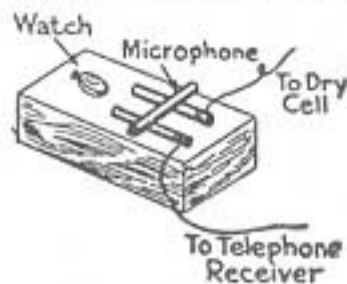


Fig. 78. Magnifying the Ticks of a Watch.

ticking of the watch will sound like grandfather's

clock racing against time.

The Noise of a Camel's Hair Brush.—The softest and smoothest thing we know about is a camel's hair brush, and when you brush anything with one you cannot hear it with your unaided ear, neither can your naked eye see that it leaves any scratches. But the microphone proves that it does both, and you can test it for yourself by rubbing it gently across the top of

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the cigar box on which your microphone rests, and listening-in at the same time.

The Thunder Factory of Jove.—In the early days of the wireless telegraph, Marconi's trans-Atlantic cableless stations used to be called thunder factories because the sparks set up noises that sounded like thunder. Now, if you will rub the free carbon against the other two of your microphone and at the same time listen-in, you will have Marconi's thunder factory beaten a mile for everything except the lightning.

The Musical Family of Insects.—Get a few live flies, or other small winged insects, and place them under a tumbler, which you then set over the microphone on the cigar box. Hold the receiver to your ear, and you will hear "Tannhauser" as played by the musicians of the insect world.

Making a Fly Imitate an Airplane.—Stick a pin into the cigar box on either side of it and at opposite

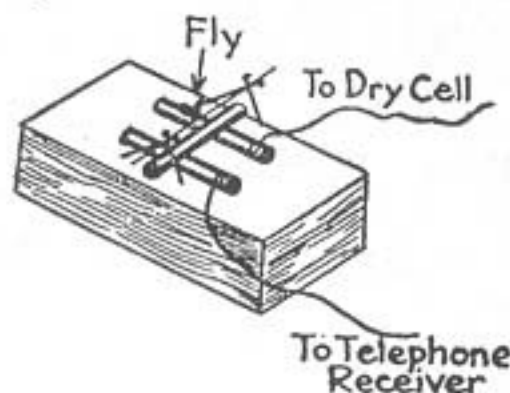


Fig. 79. A Fly Imitation of an Airplane.

ends of the free carbon, and then stretch and fasten a thread to them, as shown in Fig. 79; catch a fly and stick him on to the thread with a little honey, or

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molasses, but be sure his wings are free to buzz. Now hold the receiver to your ear and you will have a realistic imitation of an airplane as given by the fly.

The Cockroach on Parade.—Naturally, when a cockroach is on parade he walks on his feet, and these are six in all. To the unaided ear he walks silently, but if you will put him on the microphone and set an inverted tumbler over him, you will hear exactly

the way he walks when he is on parade.

How to Transmit Music by Electricity.—Place your microphone on the piano or on a phonograph, or on, or very close to, any musical instrument. Now place your receiver and battery in another room and connect them all up with wires, as previously described. Have some one play the instrument, and if you will hold the receiver to your ear, you will hear the music very distinctly.

How to Make an Ultra-Sensitive Microphone.—Cut a hole three inches in diameter in the top of a

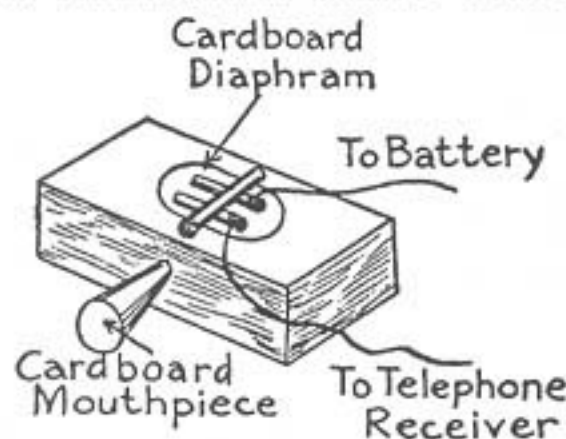


Fig. 80. The Ultra-Sensitive Microphone.

cigar box and cut out a disk of heavy writing-paper, or very thin cardboard, three and one-half inches in

diameter. Glue the disk over the hole in the box and lay the carbon microphone on the disk, as shown in Fig. 80, when you will have an ultra-sensitive microphone. By cutting a one-inch hole in the side of the box and fitting a cardboard horn in it, you can use the microphone as a telephone transmitter.

How to Make a Better Transmitter.—To make this microphone transmitter, cut a hole two and one-half inches in diameter out of the bottom of a cigar box, and a hole three-quarters of an inch in diameter out of the top of the box, so that the centers of both holes are in a line with each other. This done, glue a disk of heavy cardboard over the large hole and a cardboard cone into the small hole.

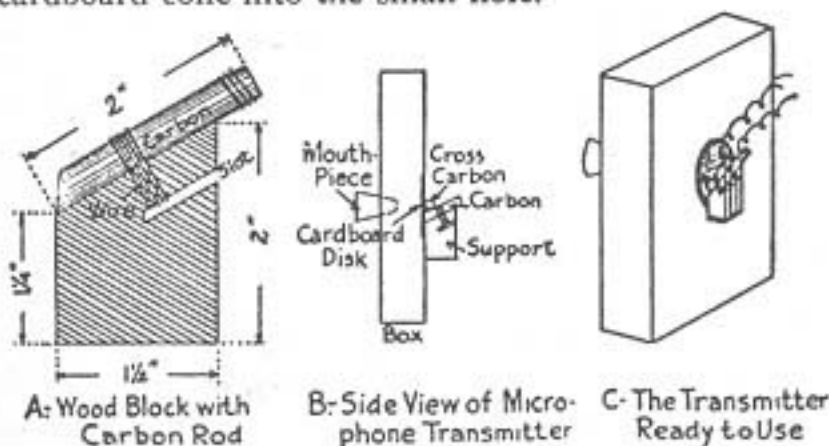


Fig. 81. How the Microphone Transmitter is Made.

Now cut out two wood blocks one-quarter of an inch thick of the size and shape shown at A in Fig. 81, and fasten a piece of carbon to each one with a bit of wire; glue these blocks of wood to the bottom of the cigar box about one inch apart, so that when you lay the free piece of carbon across them, it will roll to the

middle of the cardboard diaphragm, as shown in the side view B and the completed transmitter at C.

Connect the fixed carbons with your battery and receiver, as in the foregoing experiments, and you will have a working telephone. If your pal will make a set like yours, then you and he can run a line, which in this case must be a pair of copper wires, between your homes, and talk forth and back to your heart's content. Where two sets of instruments are used, you must connect them up as shown in Fig. 82.

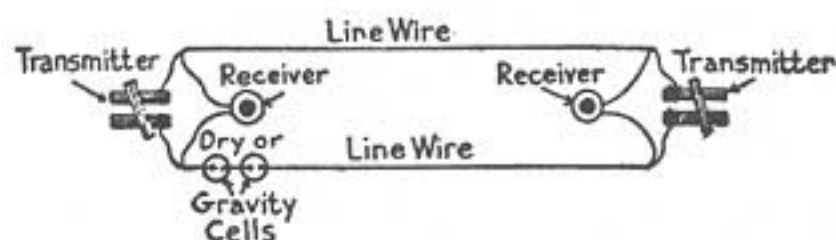


Fig. 82. Connections for a Simple Two-Way Telephone System.

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VIII

THE ELECTRIC CURRENT GENERATOR

WHILE a primary battery will generate enough current for operating bells, annunciators, burglar alarms, telegraph and telephone systems, when it comes to generating sufficient electricity for light, heat and power purposes, a dynamo electric machine, or just *dynamo*¹ for short, or *generator*,² as it is often called, must be used.

¹ The word, dynamo, is generally used to mean a direct current machine, though it is often called a generator.

² The word, generator, is generally used to mean an alternating current machine.

An electric machine can be designed so that it will either generate a *direct current* or an *alternating current* and either kind will light lamps, heat appliances, and run motors. Where, however, the generator and the apparatus that is to use the current are close together, as in homes, hotels, etc., direct current is generally used, because the operation of motors with it is more simple; if, on the other hand, the generator and the apparatus are removed from each other by a considerable distance, an alternating current is the most efficient, because the losses are less and it is more economical, for smaller wires can be used for carrying the same amount of current if a higher voltage is

used.

How an Electric Generator is Made.—An electric generator of either kind consists of only a few chief parts, and, moreover, the construction of these is very simple. Named, these parts are (1) the field magnet, (2) the armature, (3) a commutator, if direct current is generated, or slip-rings, if alternating current is generated, (4) a pair of brushes, and (5) the frame.

In the simplest type of generator the field magnet is a modified form of the familiar horseshoe magnet, and this is energized by a current, or currents, flowing through a coil wound on it. Between the poles of the field magnet there revolves a cylinder of soft iron wound with two or more coils of wire, and it is in these that the currents are set up.

The ends of the wires of these coils are connected to segments, or copper bars, fixed on an insulating cylinder, and this is called the commutator, if the generator is a dynamo, or slip-rings, if the generator is an alternator. The brushes usually consist of graphite bars, though copper strips can be employed, and these press on the opposite sides of the commutator or slip-rings and take off the currents as they are generated when they flow through the outside circuit, or *line*, as it is called.

How a Generator Sets Up Currents.—The first experiment that Michael Faraday, the great English experimentalist, made to show that magnetism could be changed into electricity, consisted of passing a wire in front of the poles of a magnet. From this simple experiment has come all the wonderful developments in light, heat and power, that have been made in electrical engineering during the last fifty years.

Now, you can perform the same classic experiment to show that the energy of a magnetic field is changed into an electric current when a wire is moved quickly through it. To do so, bend a stiff piece of copper wire into a U form and connect the ends of it with a galvanometer, such as I described in Chapter V, and have the magnetic needle parallel with the turns, as I explained there.

This done, lay a permanent steel magnet on a cigar box or other support, and move the loop up and down in front of the poles of the magnet, when you will see that the needle will swing first one way and then the other, which proves that a current flows first in one direction and then in the other in the galvanometer coil.

It must be clear now that since a magnetic field will set up a current in a single wire when the latter is moved through it by hand at a slow speed, many turns of wire, as in an armature, when made to cut through a magnetic field at a high speed will develop currents of much greater strength.

Further, and finally, the lines of force developed by the field magnet of a generator are very greatly strengthened by the use of the soft iron core in the armature (since iron conducts the lines of force with far less resistance, or *reluctance*, as it is called, than air); hence the currents set up in the armature are of proportionately greater strength.

As the coils of wire on the armature pass the north pole of the field magnet currents are set up in them in one direction, and as the coils pass the south pole of it currents are set up in them in the opposite direction, and no matter how the armature is wound, the currents set up in it are always *alternating*.

If, now, the ends of the coils on the armature are connected to a pair of copper rings called slip-rings, which are insulated from the shaft and from each other, then the currents taken off will be alternating in direction, but if a commutator is used, which consists of as many segments, or copper bars, on it as there are coils of wire on the armature, and the ends of these are connected to the segments, then the alternating currents will all be made to flow in the same direction as they are taken off by the brushes and, hence, they are *rectified*, that is, they are changed into a *direct current*, or a *continuous current*, as it is sometimes called.

Generators have their field magnets wound in three different ways, according to what they are going to be used for, and these are (1) *series* wound, (2) *shunt* wound, and (3) *compound* wound. The little generator which I am about to describe is series wound, but if it is your intention to install one large enough for practical use, then you must get a compound wound one.

About the Direct Current Generator.—While the generator which I shall tell you how to make is a simple series wound one, after you have made it you can rewind the field magnet so that it will be either shunt or compound, as you wish, and you can build a larger one with more coils on the armature.

This little generator consists of (1) the *field magnet*, (2) the *armature*, (3) the *commutator*, and (4) the *brushes*. The field magnet is made like the smaller

electro-magnets described in Chapter V, only it is considerably larger, is formed of thin sheets of iron, 137

or *laminated*, as it is called, has concave pole pieces, and a single coil of wire wound on the middle of it, instead of a coil on each leg, but you can have a pair of coils, if you want them, by a little redesigning.

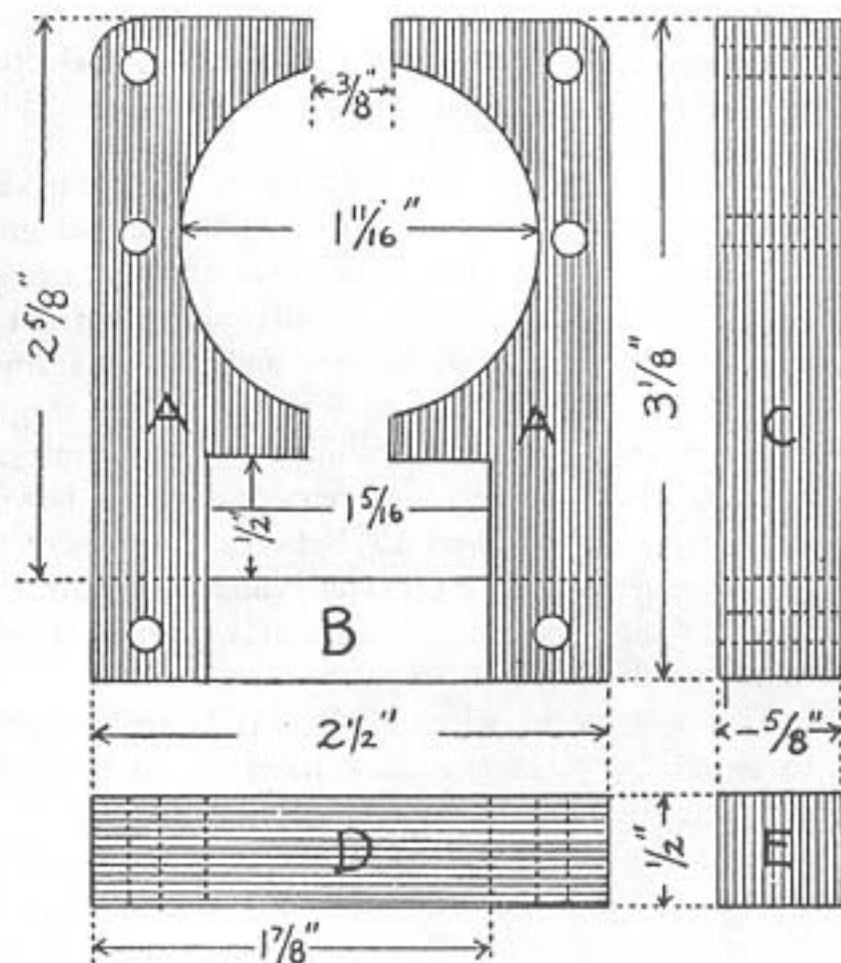
The armature, which is also built up of thin sheets of iron, becomes an electro-magnet too when currents are set up in the coils of wire. It has three poles or *polar projections*, as they are termed, but it can have as many more as you care for, by cutting slots lengthwise in a cylinder of soft iron, in which case as many more coils are wound on the armature and as many more bars are needed on the commutator. A generator built according to the following specifications, when driven at a speed of from 3,000 to 3,500 revolutions per minute, will generate enough current to light up a six volt, six candle-power tungsten lamp.

How to Make the Generator.—The Field Magnet.—To make this generator you will need a drill stock, a three-sixty-fourths of an inch and an eighth-inch drill, an 8-32 die, and a stock for cutting threads, and, of course, the necessary materials. Begin by cutting out enough pieces of tin plate, which is simply sheet iron coated with tin, or, better, thin sheet iron, into sheets two and one-half inches wide and three inches long and have enough of them to make a pile five-eighths of an inch thick.

The exact thickness of the sheet iron does not in the least matter, but the thinner it is the easier it will be to cut it to shape and the better the generator will work, for the reason that the core will magnetize and demagnetize more quickly and thoroughly. Cut the sheets out to the size and shape shown at A in Fig. 83, 138

but make half of them two and five-eighths inches long and the other half three and one-eighth inches long.

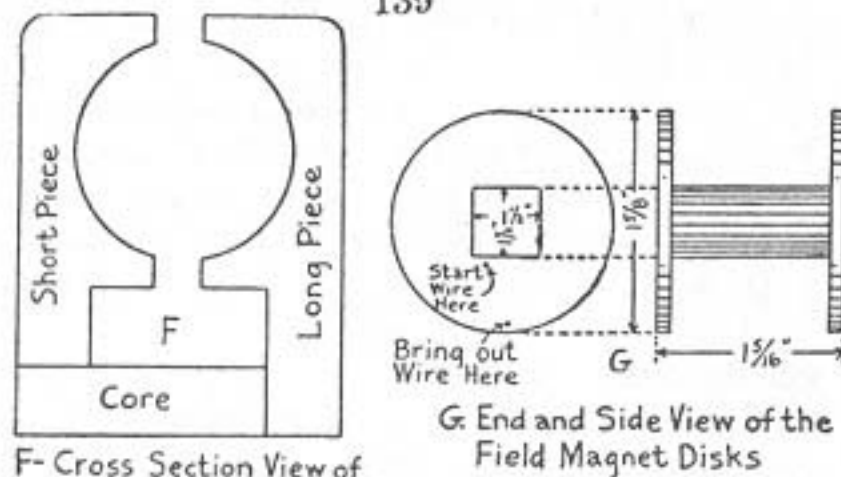
Now cut out enough strips of the sheet iron for the core to make a pile five-eighths of an inch thick of the shape shown at B, and make them one-half of an inch wide and one and seven-eighths inches long, and you are ready to assemble them into the field magnet. To do this, you lay one of the short field pieces down on the left-hand side, then a long one on the right-hand side, and one of the core strips at the bottom, as shown at F. Then keep on building up the pieces, so that the long and short ends alternate and the strips lap over them until the required thickness is reached.



- A- Side View of the Field Pieces
- B- Side View of the Core
- C- End View of the Field Pieces
- D- Top View of the Core
- E- End View of the Core

Fig. 83. The Field Magnet for the Generator.

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F- Cross Section View of The Field Magnet

(F-G) Fig. 83. The Field Magnet for the Generator.

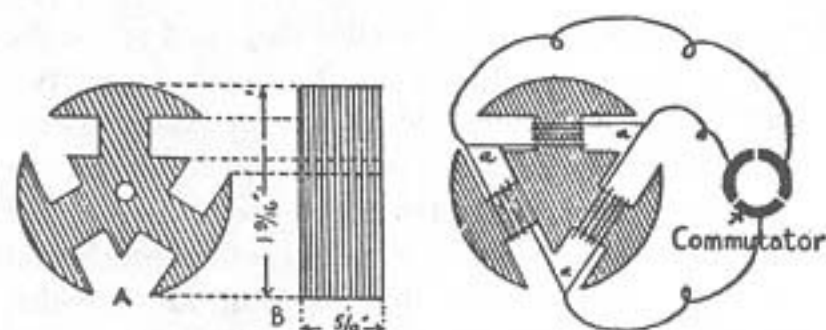
This done, place them carefully in a vise and then drill six one-eighth-inch holes through them, as shown at A, and bolt them together at the corner holes. You can now smooth the field magnet up with a file, using a half-round file for the concave parts. Give the core a coat of shellac varnish, then wind a strip of thin muslin around it spirally, and give this a coat of shellac. When it is dry take out the lower bolts and gently

pull out the core.

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Next, cut out two pasteboard disks one and five-eighths inches in diameter, and make a hole in each one one-half inch square, or a trifle larger, and slip these over the core so that they will be one and five-sixteenths inches apart, as shown at *G*, and fix them to it with shellac. Now push one end of some No. 20 single cotton covered magnet wire through one of the holes in the spool, then wind it on evenly until the latter is full. As you get each layer on give it a coat of shellac, and when it is full bring the end of the wire out of the hole in the cheek near the rim. You can now slip the ends of the strips of the core back into place in the legs of the magnet. Put the lower bolts in again and tighten them up.

The Armature.—The next thing to make is the armature core, and this you do by cutting out enough disks of sheet iron one and nine-sixteenths inches in diameter to the shape shown at *A* in *Fig. 84*, which



A- Cross Section of Armature B- End View of the Armature C- How the Armature is Wound
Fig. 84. The Armature for the Generator.

is a cross-section view of it, to make a pile five-eighths of an inch thick, as shown at *B*. Even these up, put them in a vise, and drill a one-eighth inch hole

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through the center of them; then smooth them up with a file and slip a steel rod, which is the shaft, one-eighth of an inch in diameter and three and one-eighth inches long through the hole, so that the center of the core will be one and three-eighths inches from one end of the shaft.

Now wind each groove of the core full of No. 20 gage cotton-covered magnet wire, and see to it that each coil is wound in the same direction, as shown at *C*. When you have this done, scrape the insulation from the ends of all the wires and solder the inside end of one coil to the outside end of the other coil, so that in the end all three coils will be connected in series. Then solder a short wire to each one of these joints at the places marked *a a a*.

The Commutator and Brushes.—For the commutator, get a piece of hard fiber rod seven-sixteenths

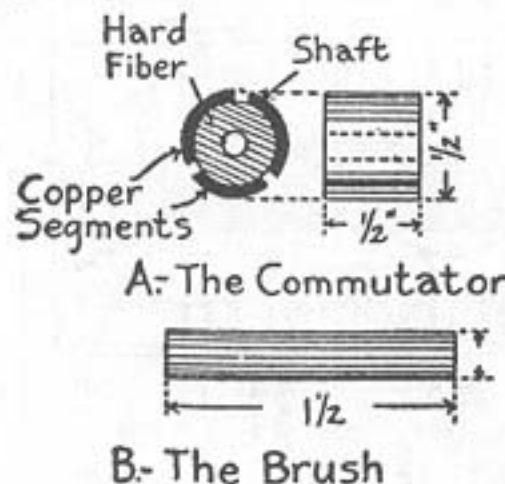


Fig. 85. The Commutator and Brushes.

of an inch in diameter and one-half inch long, and very carefully drill a one-eighth inch hole through the center of it. Then cut out three pieces of brass one-

thirty-second of an inch thick, seven-sixteenths of an inch wide, and one-half inch long, and drill a one-sixteenth inch hole in the ends of each one; bend these lengthwise to fit the curve of the fiber cylinder, and screw them to it at equidistant points, so that they will be separated, and, hence, insulated from each other, as shown at *A* in *Fig. 85*. Now force the commutator on the armature shaft, so that it will not slip and, finally, solder each terminal wire from the armature to the ends of the commutator segments.

For the brushes, cut out two pieces of thin, cold rolled (spring) copper one-quarter inch wide and one and five-eighths inches long, as shown at *B*. Roll up one end of each one with a pair of round-nose pliers, so that it will have a diameter of three-eighths of an inch, when each one can be slipped over the rods that hold the generator together.

The Frame, Frame Rods, and Sleeves.—The frame that holds the generator together consists of a pair of support plates, rods and sleeves. For the plates cut out two pieces of sheet brass one-thirty-second of an inch thick, two and seven-sixteenths inches wide, and three and one-half inches long, and drill eight one-eighth inch holes in them at the places shown at *A* in *Fig. 86*; then bend over one end of each one three-eighths of an inch to form a foot, when the plates will be three and one-eighth inches high, as shown at *A* and *B*.

For the rods that hold the generator together, cut off four pieces of brass rod one-eighth inch in diameter and two and five-eighths inches long, and thread both ends of each one with a 6-32 die, and then

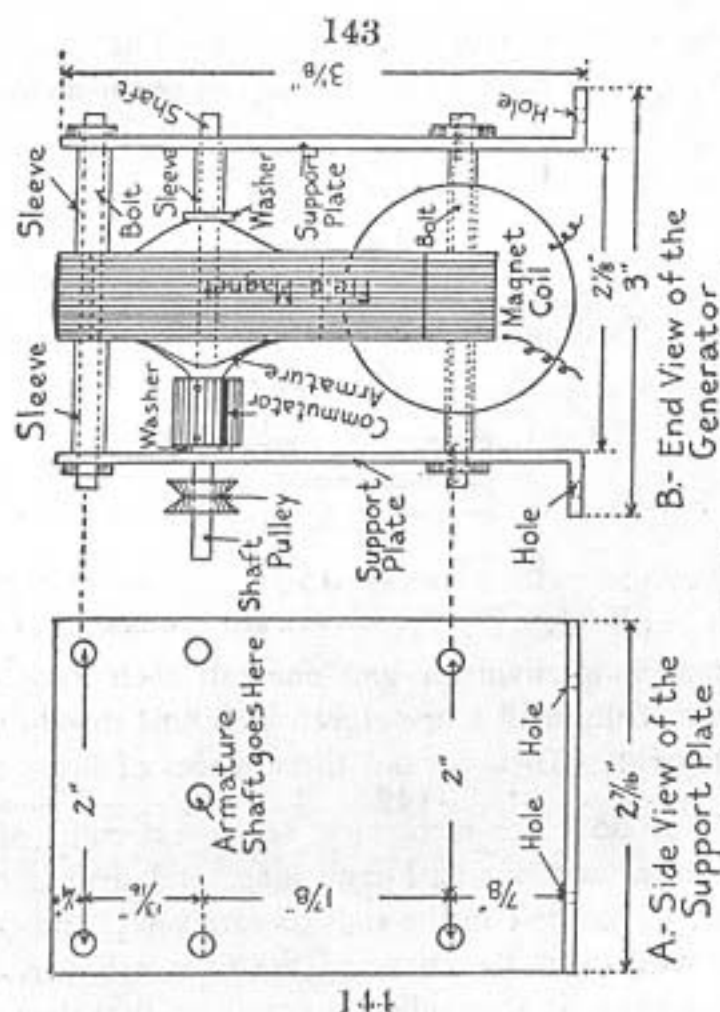


Fig. 86. How the Generator is Assembled.

get eight 6-32 nuts which will fit them. To keep the side plates at the right distance apart from the armature, get a brass tube just large enough so that it will slip easily over the rods, and then cut it off into the following lengths:

Eight pieces three-quarters of an inch long for the two top and bottom rods; two pieces three-sixteenths of an inch long, and two pieces one and eleven-sixteenths inches long for the brush rods, as shown at *A* and *B* in Fig. 87, and one sleeve for the armature shaft, as shown at *B* in Fig. 86; get, also, a couple of small washers that will slip over the armature shaft. When you have all of these parts together, you are ready to assemble your generator.

How to Assemble the Generator.—The first thing to do is to slip the ends of the armature shaft through the middle holes in the support plates, and then push the threaded rods through the two upper and the two lower holes of the plates and the field magnet, slipping on the sleeves as you go along, and then screw a nut on each end of each rod. Next push the brush rods through the holes of the plates and the magnet, which are in a line with the armature shaft, and slip the sleeves and brushes on their respective rods, but you must insulate the brushes from the rods with hard fiber, or with paper which you can wrap on the rods and shellac. Now, when you screw the nuts

on the ends of the rods, the brushes will be held firmly in position so that they will press on the commutator with any degree of tension that you want. Finally, fix the pulley on one end of the shaft.

Get a board for the base about one-half inch thick,

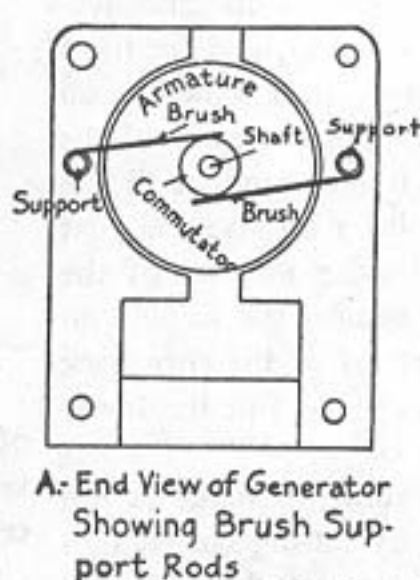
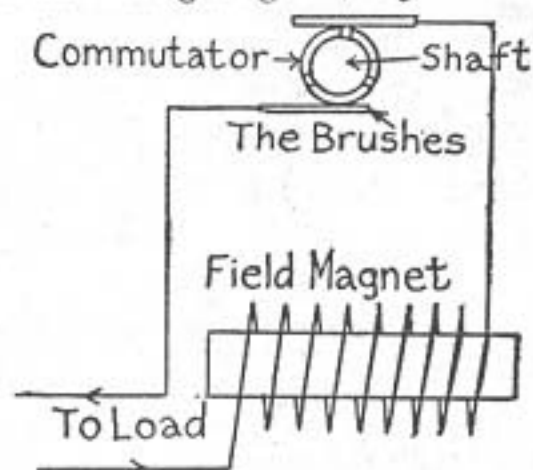


Fig. 87. The Brushes and Their Supports.

three inches wide, and four inches long, and screw the support plates down firmly to it. Next screw two binding posts on the base, when you are ready to connect one of the ends of the magnet coil to one of the binding posts, and solder the other end to one of the brushes; solder another wire to the other brush and connect this with the other binding post, all of which is shown in the wiring diagram, Fig. 88. Your gen-



erator is now complete (See Fig. 89) and ready to generate current, but, of course, the armature must be driven at a fairly high speed.

How to Make an Alternating Current Generator.—To make a generator that will deliver an alternating current, you need only to wind the armature as you did for the direct current machine described above, but instead of tapping the connections between the coils and fixing them to the segments of a commutator, you connect the coils together and bring the end of the

beginning of the first coil and the end of the last coil out, as shown in the diagram at *A* in *Fig. 90*, and connect these with a pair of slip-rings.

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The slip-rings, which take the place of the commutator of a direct current generator, are formed of a pair of brass or copper rings secured to the ends of a

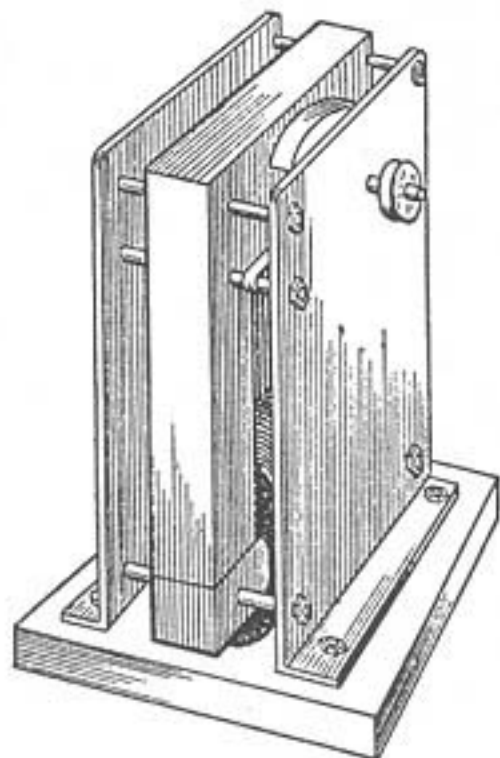


Fig. 89. The Generator Complete.

cylinder of fiber about one-half inch in diameter, usually by pins, as shown at *B*, and this has a one-eighth-inch hole drilled through its center, so that it can be put

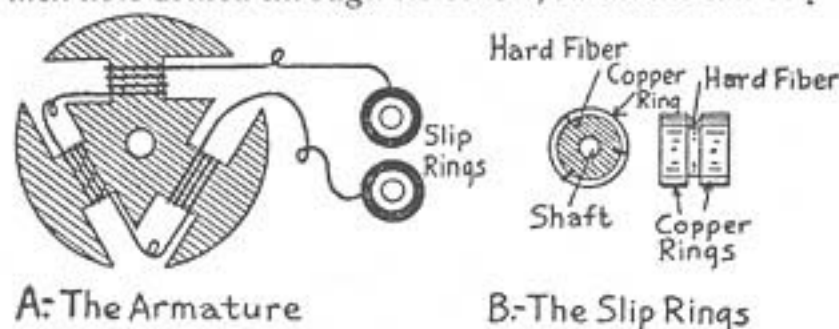


Fig. 90. How the Armature is Wound.

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on the shaft carrying the armature. One of the brushes is made to press on one of the rings and the other brush is made to press on the other ring.

Since alternating currents would set up a corresponding alternating magnetic field, the field magnets must be energized by a direct current, and this you can do by connecting the field coil with a battery or other source of direct current. The way in which the alternator is connected up is shown in *Fig. 91*.

How to Drive the Generator.—There are a number of ways by which you can drive the generator, as, for instance, with the flywheel of a scroll saw or sew-

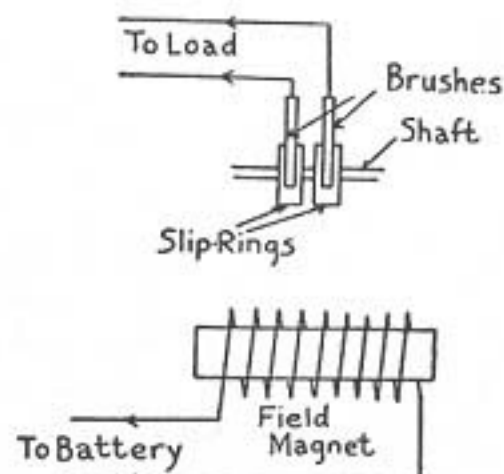


Fig. 91. How the Alternating Current Generator is Connected Up.

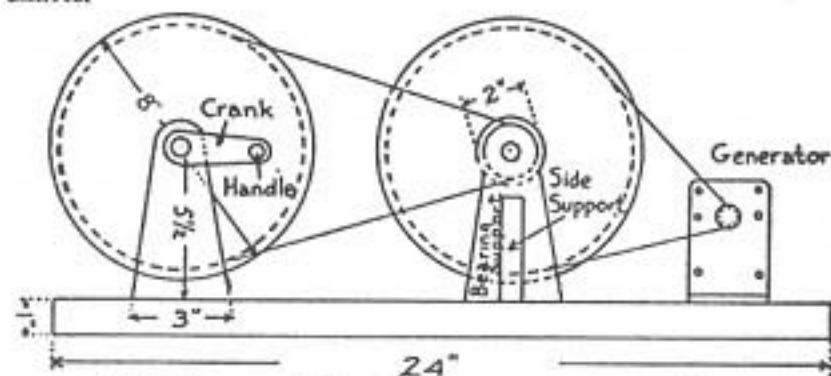
ing machine, with a water motor or a steam engine, but it is not always an easy matter to get hold of one of these machines. What you can do, however, is to make a hand-power drive and belt it to the pulley of the generator.

To make a drive of this kind, get three wooden grooved wheels one-half, three-quarters or one inch

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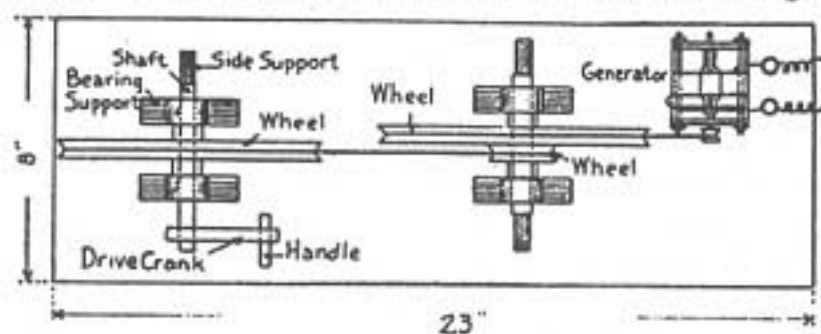
thick, and have two of them eight inches in diameter and the third one two inches in diameter, as shown in the side view at *A* in *Fig. 92*. Mount the wheels on wooden shafts one-half inch in diameter and six inches long,¹ and make a crank for one of them, as shown at *A* and *B*.

¹Dowels, which you can get at a carpenter shop, make good shafts.



(A) Fig. 92. Side View of the Generator Drive.

Next, cut out four standards, for the bearings, of hard wood one-half inch thick, and have the top ends of them one inch wide, the lower ends three inches wide, and all of them five and one-half inches in length.



(B) Fig. 92. Top View of the Generator Drive.

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Also cut out four braces for the standards and let these slope from one-half inch at the top to one and one-half inches at the bottom, and have them three inches long.

Now slip over the ends of each shaft a collar made of wood, or hard fiber, and then put the ends of the shafts through the holes, or bearings, of the standards. This done, saw out a base-board of wood one inch thick, eight inches wide, and two feet long, then screw the standards to it at the places shown at *A* and *B*, and to hold these rigidly in position screw the braces to the outsides of each one and to the base.

Glue the crank to one end of the shaft that carries the single wheel. Then belt the large wheel that is driven by the crank to the small wheel and belt the large wheel that it is fixed to, to the pulley of the generator. You can start to generate current forthwith by turning the crank, and when you get it up to speed you will have enough current to perform any of the experiments with that I have previously described in Chapter IV.

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IX

THE ELECTRIC MOTOR

AWAY back in the early days of electric lighting some genius—or fool—discovered that when an electric current flowed through a generator it would run as a motor. It is thought that this far-reaching discovery may have been made unwittingly by some one who accidentally connected two generators together. Be this as it may, all you need to do to change your generator into a motor is to take away the driving power and turn an electric current into it.

For the current to drive your motor, you can use either (1) a primary or a storage battery, or (2) a direct or alternating current generator. A primary battery will run the motor for short periods of time, but when the motor has to do work and must be run continuously, then a current from a storage battery or a lighting circuit gives far and away the best results.

How to Run Your Motor.—1. *With a Battery.*—Where a battery is the only source of current available, dry cells, and all other open circuit cells, can be used, but they run down very quickly. A battery of gravity cells, or of Bunsen cells¹ will give fairly good results, and where the motor is to be used only a few minutes at a time a bichromate of potash battery, or plunge battery, as it is called, will give the most power-

¹ See Chapter III.

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ful current. A storage battery will run the motor continuously until it is discharged, but as it (the battery) is costly to begin with and must be recharged, it is not within the means of every amateur, and even when it can be had it is more or less troublesome.

2. *From 110-Volt Direct Current Service Wires.*—If your home is wired for electric lighting and it supplies direct current, you can use it for running your motor by cutting the pressure down to ten volts or less; this you can do by connecting a *variable resistance*, or *rheostat*, in the circuit. You can make a simple resistance, which you can vary, by getting six one-pint jars and filling them three-fourths full of water, and then stirring into the jars one-half pint of sulphuric acid.

Now cut out twelve plates of sheet lead one-sixteenth inch thick, two inches wide, and six inches long, and solder, or otherwise fix, a piece of No. 14 wire to one end of each one. Set two of these plates, or *electrodes*, as they are called, into each jar and connect them together in *series-parallel*, as shown in the wiring diagram in *Fig. 93*. Now connect the two end plates that are nearest your motor with one of its binding posts, and connect the other post with the two other end plates.

This done, cut one of the strands of an electric light cord, the terminals of which are connected with a 32 candle-power lamp, and connect one end of the strand to the end plates nearest the motor, and the other strand to one terminal of the motor. When you turn on the lamp-switch, a part of the current will flow through the *water resistance*, as it is called, and part

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To 110 Volt
Lamp Socket

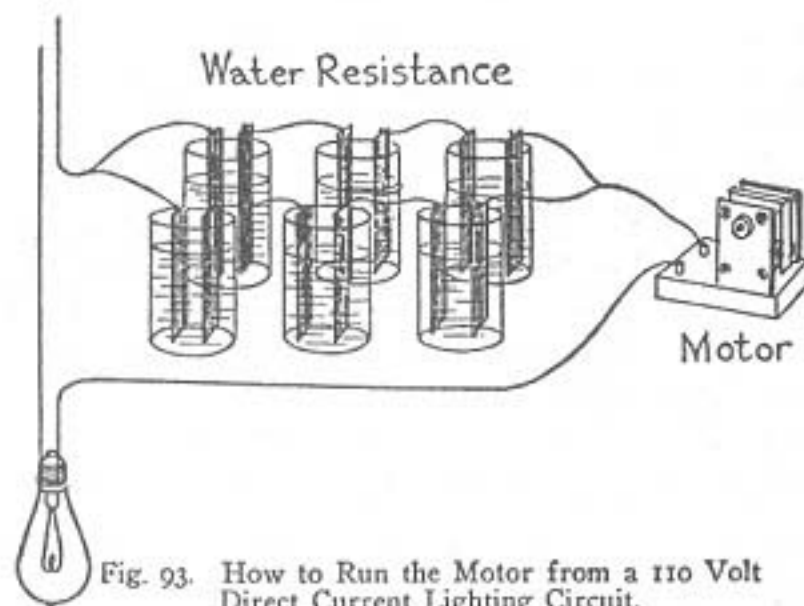


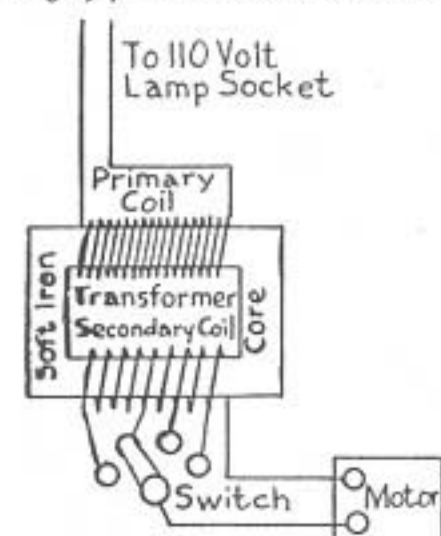
Fig. 93. How to Run the Motor from a 110 Volt Direct Current Lighting Circuit.

of it through your motor. Your motor will take whatever amount of current it needs to run it, and the water resistance will absorb the rest of it by converting the energy of it into heat.

3. *From 110-Volt Alternating Current Service Wires.*—An alternating current will drive your motor without changing any of the connections that you use for direct current. Hence, where the service wires carry 105 to 115 volts alternating current, you can use it, but, as with the 110-volt direct current, you must reduce it to an amount small enough so that it will not burn out your motor.

The best way to do this is to use what is called a *toy transformer*; this is a little piece of apparatus that

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steps-down the voltage, which is the electrical pressure, of the 105 to 115-volt current. This it does by electro-magnetic induction, and it consists of two coils of wire wound on a soft iron core, as shown at A in Fig. 94. The coil that is connected with the lamp cord



A. Wiring Diagram of a Toy Transformer



B. The Toy Transformer Complete

Fig. 94. How to Run the Motor from 110 Volt Alternating Lighting Circuit.

of the service wires is called the *primary coil*, while the one connected with the motor is called the *secondary coil*.

To step-down a 100-volt current to 10 volts, you must have ten times as many turns of wire on the primary coil as there are turns on the secondary coil, that is, the ratio of the turns must be as ten is to one. Now, a small transformer of this kind that you buy in the electrical shops has wires tapped off at different turns of the secondary coil, and each of these leads to a button, or point, on the switch, as shown at B.

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This arrangement makes it possible to vary the pressure by steps of three volts; thus when you move the

lever so that it makes contact with the first button, or point, you will get a current of three volts, when you move it to the second you will get six volts, the third will give you nine volts, and the last twelve volts, which is as high a pressure as it is safe to use on small motors. By varying the voltage in this way, the speed with which the armature rotates and the power that the motor develops is, naturally, varied accordingly.

How the Motor Works.—*The Active Poles of the Armature.*—The core of the armature has, in this particular motor, three poles and each one is wound with a separate coil of wire. If you will connect any two of the terminal wires with a dry cell, and test the magnetic strength of each pole by holding a nail on it, you will find that two of them are magnetic, while the third is not. One of the active poles is the *north pole*, the next one is the *south pole*, while the third is the *neutral pole*.

To Test the Polarity of the Armature Poles.—If you want to find out which is the north pole and which is the south pole, you need only to connect up the armature to a dry cell, as described above, and bring the needle of a compass close to each one of the poles in succession, when it will point them out, the pole that does not act on it being, of course, the neutral pole.

Since this is the case when the armature is made to rotate in the motor and the brushes make contact with the segments of the commutator one after the other,

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the current flowing through the coils is reversed every time the armature makes half a revolution; consequently, the poles of the armature change from north to south, and then to neutral successively, when the cycle is repeated. In the meantime, the poles of the field magnet remain fixed, that is, one is a *north pole* and the other is a *south pole* all the time.

When the Motor is Running.—When a current from a battery, or some other outside source, is made to flow through the motor, it energizes the field magnet first; then it passes through the connecting wire to the first brush, when the commutator takes it off and it is conducted to the coils of the armature. On leaving these it flows again to the commutator, where it is taken off by the other brush, from which it goes back to the battery or other source of power.

Now let us find out what happens when the current flows through the armature. As it does so, the circuit is completed through two of the segments of the com-

mutator, since two of the armature coils are connected with it at the same time. As it passes into one coil by the outside end of the wire and into the next coil by the inside end of the wire, the cores are magnetized oppositely, so that one of the polar projections, as the free ends of the poles are called, is *north* and the other one is *south*.

It must be clear now that since the two poles of the armature are of opposite signs, that is, *north* and *south* respectively, they are attracted to the poles of the field magnet, which are also of opposite signs, and pull them to them, thus turning the armature around. At the instant when the magnetized poles of the armature

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are exactly in a line with the poles of the field magnet, the current is reversed by the commutator, and this reverses the poles of the armature when the poles of the field magnet, which are always fixed, repel them, and this pushes the armature around, when the third coil is magnetized and the second one is de-magnetized.

Turn the armature around slowly, and you will see that the brush moves across the slot that separates the segments of the commutator at the precise moment when the poles of the armature are just opposite those of the field magnet.

How Your Motor Develops Power.—The *pull* and the *push* of the field magnets on the poles of the armature, or the *attraction* and *repulsion* of them, as it is called, causes the armature to rotate as you have seen above. This being true, it is evident that the power developed by a motor depends on the strength of the magnets. As the armature poles and fields are electro-magnets, the strength of them increases with the amount of current that energizes them.

But to develop more power, you need a larger motor for the reason that a point is soon reached when the armature and field magnets cannot be further energized by increasing the input of current. This is due to the fact that the iron cores can be magnetized only to a certain extent, and this is called the *saturation point*. In other words, iron when magnetized acts quite like a sponge dipped in water, and that is, it will absorb just so much and when it is *saturated* it will not take up any more.

To Make the Motor Reverse Its Direction.—You can make either pole of your field magnet the north

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pole and the other pole the south pole, by which I mean that you can reverse the polarity of them by the simple expedient of changing about the connection of

the ends of the field coil with the ends of the wires of the battery. To find out which pole is which, you can test them with your compass.

To reverse the direction of rotation of the armature, that is, to make it run the other way, you do not need to rewind either the field magnet or the armature. All you have to do is to reverse the direction of the current flowing into either the field magnet or in the armature, but not in both at the same time. A simple, quick and efficient way to do this is with a reversing switch.

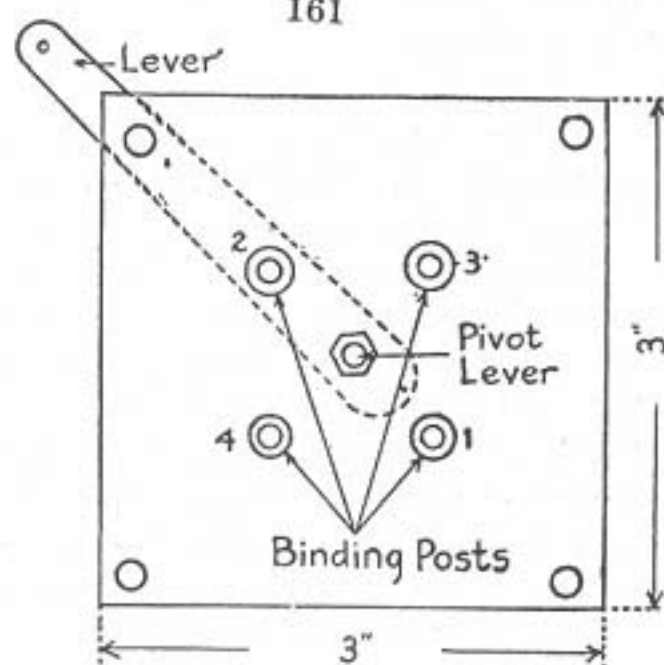
How to Make a Reversing Switch.—To make a reversing switch, get a piece of wood one-half inch thick and three inches on each side for the base, and a sheet of hard fiber¹ one-sixteenth inch thick and two and one-half inches on the sides for the support for the parts of the commutator.² Then make a lever out of a strip of hard fiber one-quarter inch wide at one end, one-half inch wide at the other end, and three and one-quarter inches long, and all of which is shown at *A* and *B* in *Fig. 95*.

¹You can use cigar box wood, but fiber is better, as it will not break.

²This means the commutator of the reversing switch, and not the commutator of the motor.

Now drill nine one-eighth inch holes through the hard fiber support plate at the points, which are also shown at *A* and *B*. Next cut out four plates of sheet brass, or copper, one-quarter inch wide and three-quarters of an inch long, and drill a small hole in the

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A. Upper Side of the Hard Fiber Plate

end of each one and rivet them to the hard fiber plate. This done, screw four small binding posts to the other side of the fiber plate, which is the top of it; twist a

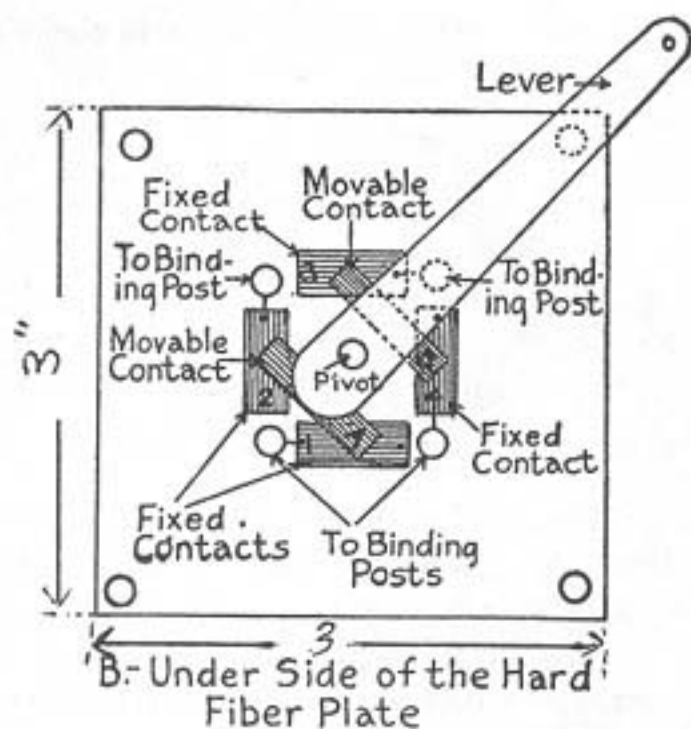


Fig. 95. The Parts of a Reversing Switch.

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wire around each binding post screw, and screw the nut up tight and then solder the free end of each wire to one end of its respective plate.

To make the movable contacts, drill a one-eighth inch hole through the lever, so that the center will come to within one-half inch of the large end. Then cut out two plates of brass, or copper, three-sixteenths of an inch wide and seven-eighths of an inch long, and bend up the corners of them slightly; drill two small holes near the middle of each one and rivet them to the large end of the lever on opposite sides of the hole and so that each one will be three-sixteenths of an inch from the center of it.

Finally, pivot the lever to the fiber plate by means of an 8-32 machine screw that is three-eighths of an inch long; then pass this screw through them, and screw a hexagonal nut on the end of it. This completes the *commutator*, as this part of a reversing switch is called. To mount it on the base, cut out two blocks of wood three-quarters of an inch thick, one-half inch high, and about one inch long; smear a little glue on one side of them and set them on the opposite sides of the base, as shown in Fig. 96, when your reversing switch is finished and ready to be connected in circuit with the source of power and your motor.

How to Connect in the Reversing Switch.—To use the reversing switch, begin by connecting the post of it marked 1 in Fig. 97 to the brush marked A of the motor, and connect the post 3 with the B brush; next

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connect post 2 of the switch with the zinc pole of the battery, then connect post 4 of the switch with the C

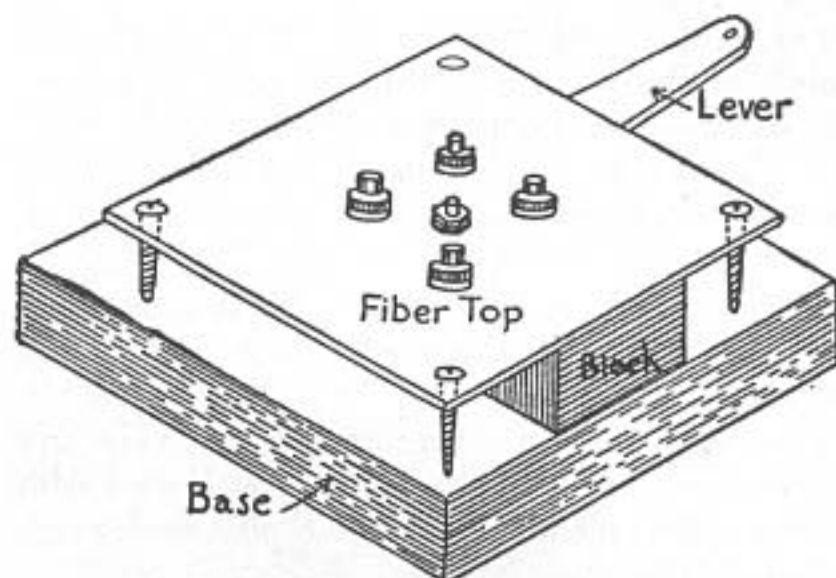


Fig. 96. The Reversing Switch Complete.

post of the field magnet, and, finally, connect the D

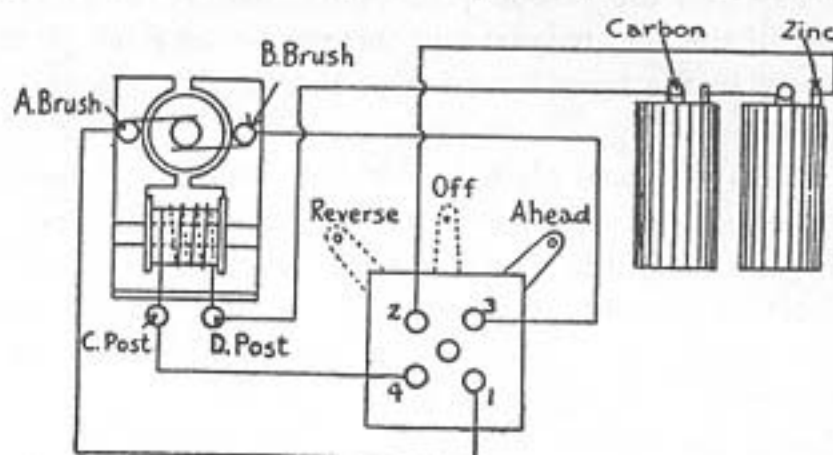


Fig. 97. How the Reversing Switch is Connected in Circuit.

post of the latter with the carbon pole of the battery.

How the Reversing Switch Works.—If now you will take a look at the wiring diagram A in Fig. 98,

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which shows the commutator of the reversing switch in the first, or ahead, position, you will see that the A plate on the lever makes contact with the fixed plates 2 and 3 and 1 and 4.

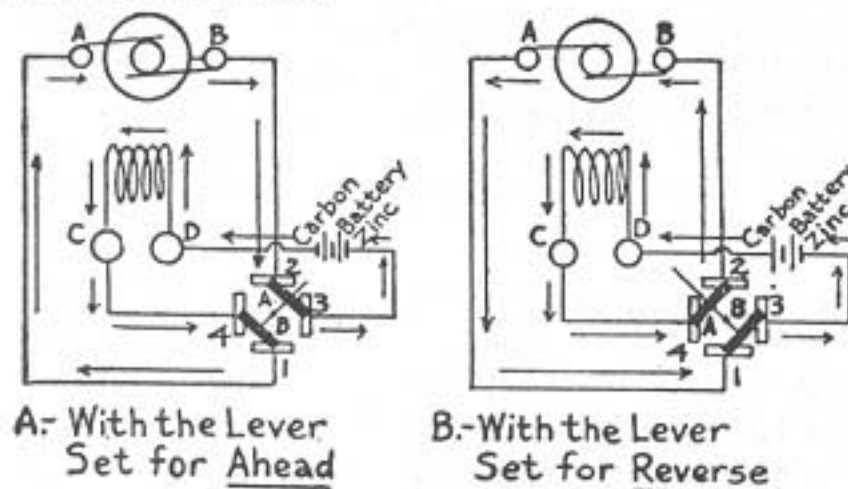


Fig. 98. Wiring Diagrams Showing the Action of the Reversing Switch.

It will be clear now that the current starting from the carbon pole of the battery will flow through the

coil of the field magnet in the direction shown by the arrows and then on to the fixed plate 4. From plate 4 it flows through the *B* plate on the lever to the fixed plate 1, when it goes to the *A* brush of the motor; from this brush it passes through the armature and out of the *B* brush in the direction indicated by the arrows; it then flows to plate 2 and through the plate *A* on the lever to the fixed plate 3, which is connected with the zinc pole of the battery.

Now, when you throw the lever over to the reverse position, the *A* plate of the lever makes contact with the fixed plates 2 and 4, while the *B* plate makes con-

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tact with the fixed plates 1 and 3. By looking at the wiring diagram *B*, you will see that the current as it flows from the carbon pole of the battery to the *D* post of the field magnet and then on to the fixed plate 4 goes in the same direction as before, as the arrows show.

From the fixed plate 2, however, the current flows to the *B* brush and then on through the armature, out through the brush *A* and on to the fixed plate 1 in the direction shown by the arrows, which, as you will observe, is exactly *opposite* to the direction it took when the lever was in the *ahead* position. From the fixed plate 1 the current flows through the *B* plate on the lever to the fixed plate 3, when it returns to the battery through the zinc pole.

What the "Load on a Motor" Means.—The load on a motor means the work it is doing. As an analogue, when a horse is pulling an empty wagon, it has little or no load—but when it is pulling a wagon with something in it, it has a load. Just so with a motor, for when it is not running a machine it has no load on it, but when it is belted to a machine and it is made to drive it, it does work and then it has a load on it. The amount of the load on the motor depends on the power it has to develop to do the work required of it.

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X

SOME EXPERIMENTS WITH YOUR MOTOR

THERE are a large number of scientific experiments that require a high speed, and I have selected about two dozen of the most striking ones that you can perform with your motor. In most of these experiments the motor sets upright, that is, in its normal position, when the shaft is horizontal, while in others it must be turned on its side so that the shaft is vertical. An

easy way to secure it in any position is to clamp the frame in the jaws of a small vise.

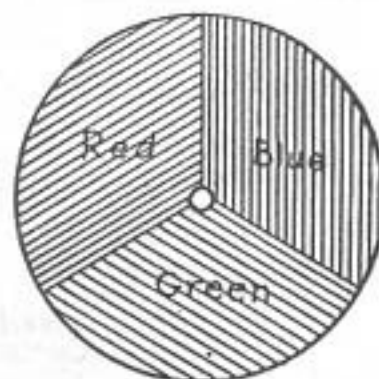


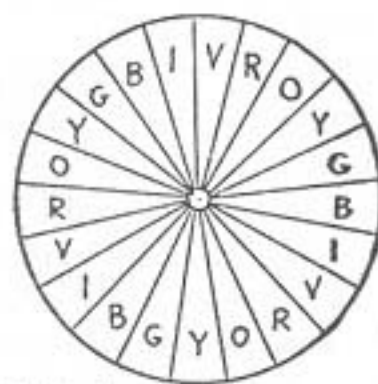
Fig. 99. The Dissolving Colors.

The Dissolving Colors.—*White light*, that is, ordinary light as it comes from the sun or an electric light, is formed of three primary colors, and these are *red, green and blue-violet*. To demonstrate this, cut a disk out of pasteboard three inches in diameter and divide it into three equal parts, as shown in *Fig. 99*.

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Now get three colors of tissue paper, namely, red, green and blue-violet, and cut them out to fit the spaces, and paste them on the disk. This done, punch a hole in the center of the disk and slip it on the shaft of your motor. Turn on the current, and when the disk is rotating fast enough the three colors will merge into each other and make the surface look as if it were nearly white.

The Colors of the Spectrum.—When a beam of sunlight is made to pass through a prism it is split up



R-Red G-Green
O-Orange B-Blue
Y-Yellow I-Indigo
V-Violet

Fig. 100. The Colors of the Spectrum.

into seven colors, and these are red, orange, yellow, green, blue, indigo and violet. If, now, you will divide the cardboard disk into twenty-one spaces, as shown in *Fig. 100*, then paste on bits of colored paper in the order given above, and slip it on the shaft of your motor, it will appear to be perfectly white when

it gets up to full speed. If the disk takes on a gray or a muddy color when it is rotating, it is because the

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colors of the tissue paper are not exactly of the right shade.

How Red and Green Make Yellow.—When red and green light are mixed together, they make yellow light. To make this pretty experiment, cover half of the pasteboard disk with red paper and the other half of it with green paper. Slip the disk on the shaft of your motor, turn on the current and the two colors will merge into yellow. If you will get a book on physics, you will find out all about primary and complementary colors and light and shade, and from this knowledge you will be able to devise many other interesting experiments.

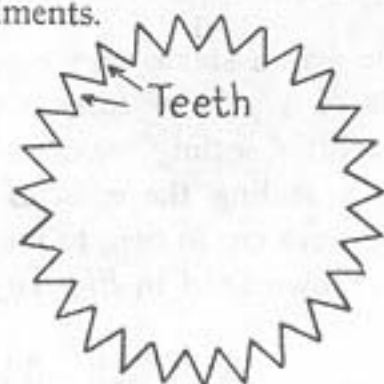


Fig. 101. The Buzz Saw.

A Buzz Saw Experiment.—Of course you have made buzz saws of cardboard disks, and driven them at high speed with a twisted cord. Well, here is a better one, because it leaves your hands free to do other things. Cut a saw-tooth edge on a cardboard disk that is three inches in diameter, as shown in Fig. 101, then mount the disk on the shaft of your motor and start it running.

Now hold the edge of a thin card against the rapidly

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moving toothed wheel, when it will give out a musical note. By cutting out a number of disks and cutting different numbers of teeth on their rims, you can obtain various musical notes. Then, if you will space the teeth unevenly, when you hold a card against them,

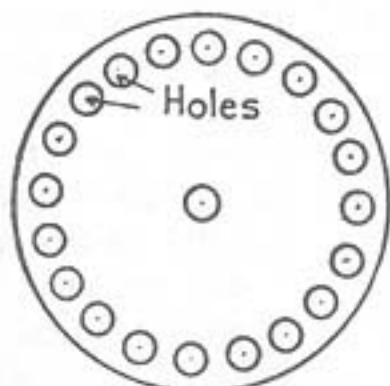


Fig. 102. The Siren.

peculiar harsh noises will be set up.

The Song of the Siren.—Punch a ring of evenly spaced holes around the edge of a cardboard disk three inches in diameter, as shown in Fig. 102, and mount it on the shaft of your motor. Now get a piece of rubber tubing one-quarter inch in diameter and about a foot long, and place one end in your mouth and hold the other end close to the ring of holes. Start up your motor and blow through the tube, when the disk will give out a musical note. You can vary the experiment by punching a ring of unevenly spaced holes around the edge of the disk, rotate it, and blow through the tube as before, when a curious noise will be emitted.

The Whirling Chain.—This is an experiment that shows in a striking manner the effects of centrifugal force on a rapidly rotating chain. Get a small

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chain of any kind or material—a watch-chain is good—of such a length that when the ends are fastened together and it is spread out in the form of a ring it shall have a diameter of about three inches.

Now tie one end of a thread to the chain at any point, and tie the other end of the string to the shaft

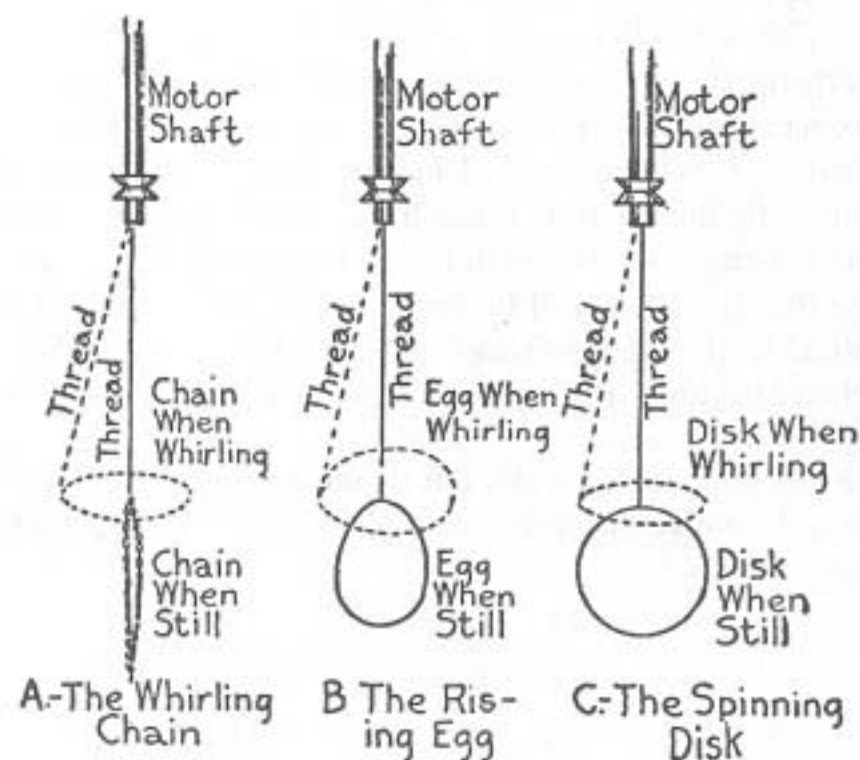


Fig. 103. Curious Effects of Centrifugal Force.

of your motor, so that the chain hangs down as shown at A in Fig. 103. Now start up your motor, when the centrifugal force will make the chain spread out in a ring and whirl in a horizontal plane. This experiment proves that the tendency of a body is to rotate about its shortest diameter.

The Rising Egg.—Columbus showed the world

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how to make an egg stand on its end, but here is a trick with one that the great discoverer did not know anything about. Take a fresh egg (and be sure it is fresh) and make a hole about one-eighth inch in diameter through the shell at both ends.

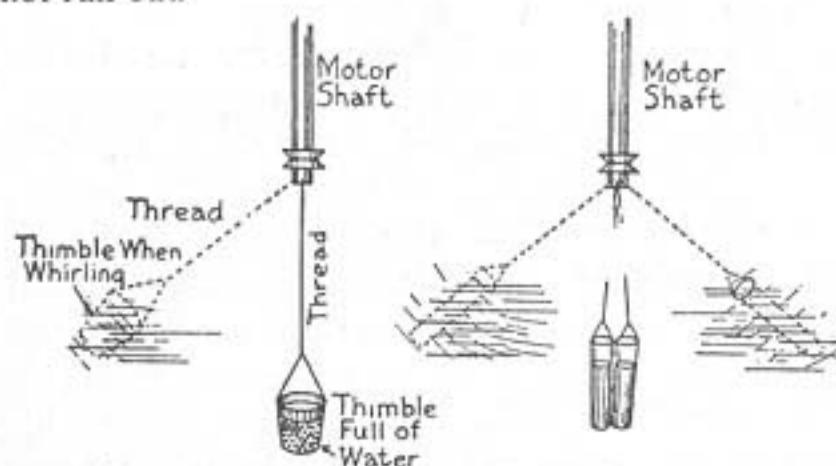
This done, carefully blow out the contents and then fasten a thread to the small end of the shell with a drop of sealing wax, and tie the other end of the thread to the shaft of your motor. Now hold, or, better, fix your motor in a vise so that the shaft is vertical, and slowly start up the motor, when the centrifugal force will make the egg whirl about its shortest diameter and so bring it to a horizontal position, as shown at *B*.

The Spinning Disk.—Tie a thin wire to the edge of a metal disk that is about three inches in diameter, and tie the other end of it to the shaft. Now hold, or fix your motor in a vise so that the shaft is vertical, and turn on the current slowly. When it gets up to speed the centrifugal force will make the free edge of the disk rise until it is level with the edge that is tied to the wire, when the whole disk will be spinning in a horizontal plane, as shown at *C*.

The Unspillable Pail of Water.—This is an old experiment in a new form. Fix a piece of No. 24 copper wire around the top of a thimble to form a bail on it, as shown at *A* in *Fig. 104*. Now suspend the little bucket thus made by a thread from the end of the shaft of your motor, and fix the latter in a vise so that the shaft will be vertical and steady. Fill the thimble full of water and turn on the current, when the centrifugal force, as the motor gathers speed, will

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throw the bucket up and out of the vertical plane until it will revolve in a horizontal plane and the water will not run out.



A—The Water That Can't Spill

B—A Cream Separator

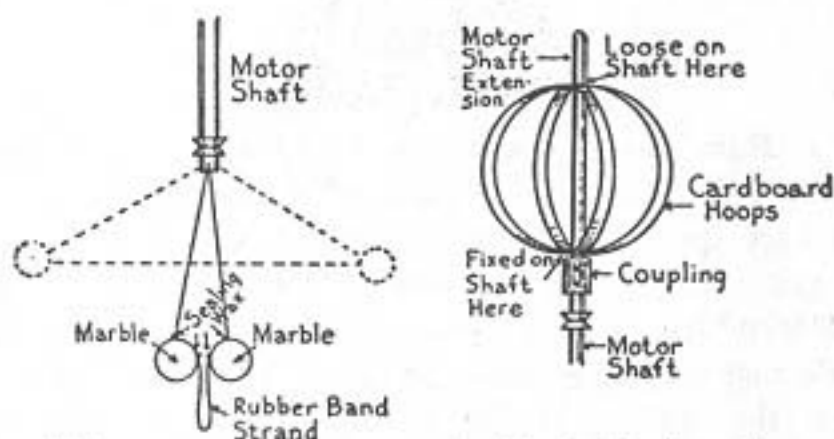
Fig. 104. Gravitation Versus Centrifugal Force.

The Centrifugal Cream Separator.—Go to the druggist and get two of the smallest pill bottles he has, and tie a strong thread around the neck of each bottle, and tie the other ends to the shaft of your motor. Fix the motor in a vise with the shaft in a vertical position as at *B*, and turn on the current. As the speed increases the little bottles will fly farther and ever farther apart, when the water, which is heavier than the butter-fat, will be thrown to the bottoms of the bottles. This is the principle on which the regular centrifugal separators are made.

How a Steam Engine Governor Works.—The action of centrifugal force is used in many ways in various kinds of machines, and it is the opposing force that controls the operation of a steam-engine governor.

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To illustrate the way a steam-engine governor works, fasten the ends of a pair of threads to a couple of marbles with a little sealing wax, and then connect them together by sealing the ends of a thin rubber band, which you have cut in two, to the marbles of the sealing wax, as shown at *A* in *Fig. 105*.



A—How a Steam Engine Governor Works

B—Why the Earth is Flat at the Poles

Fig. 105. Two Practical Experiments With Centrifugal Force.

Tie the free ends of the strings to the end of your motor shaft and start your motor up slowly; then increase the speed, by means of a water resistance, or other *rheostat*, when you will see the marbles gradually spread apart until the rubber band will stretch out, as shown by the dotted lines. This is exactly what the balls do of the steam-engine governor, and in so doing they work a valve which cuts down the flow of the steam from the boiler to the cylinder of the engine.

Why the Earth is Flat at the Poles.—To perform this experiment, you will have to connect an extension shaft, which is a steel rod about four inches long, to the shaft of your motor by means of a sleeve,

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as shown at *B* in *Fig. 105*. Now make two hoops

at *A* in *Fig. 108*. Next paste a piece of black tissue

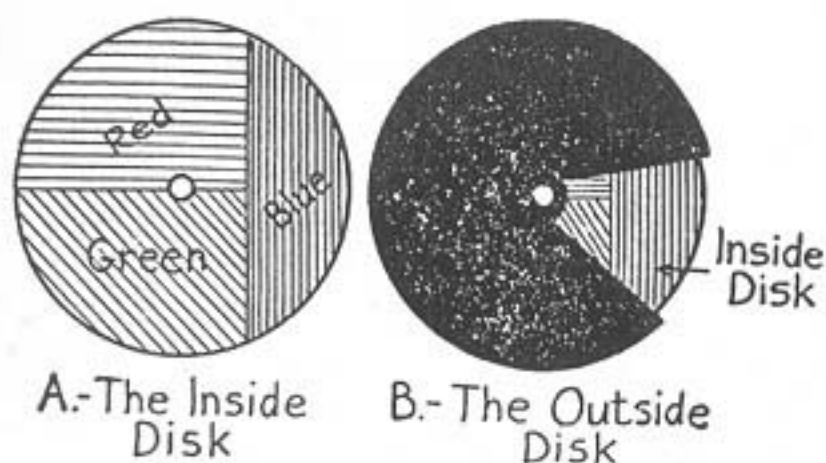


Fig. 108. The Chameleon Colors.

paper on the other disk and cut a section out of it, as at *B*; this done, make a hole in the center of the *A*, or color, disk so that it will fit tight on the motor shaft, and make a hole in the center of the *B*, or sector, disk so that it will slip around easily on the shaft.

Now put them on the shaft, then start up your motor, and look at the color disk through the sector disk, and as you do so change the speed of the latter by touching its rim with your finger, when it will change its position with reference to the color disk; this will have the effect of making the colors run together and form various colored circles whose values constantly change. This phenomenon is due to the persistency of vision.

The Prohibition Jag-o-Scope.—This device should be in the hands of every prohibitionist with a thirst for knowledge, whether real or acquired. To make it, cut out two pasteboard disks three inches in diameter, and divide one of them into two sets of radial bars, one inside the other, as shown at *A* in

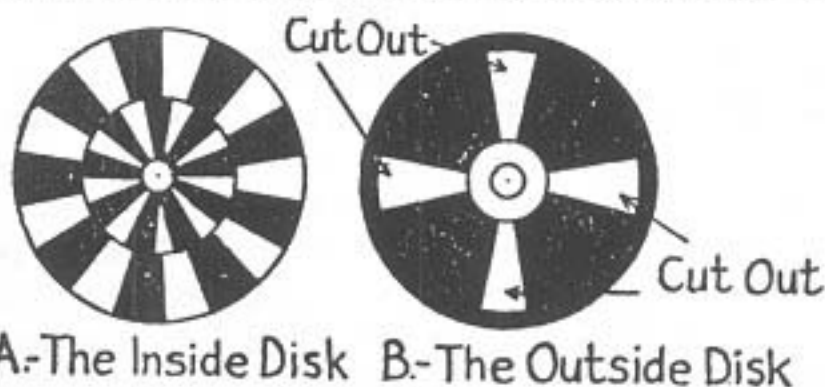


Fig. 109. The Prohibition Jag-o-Scope.

Fig. 109. You can put in the radial bars with India ink, or any other good black ink.

Next cut four radial slots in the other disk, as shown at *B*, then punch a hole in each disk and mount the radial bar disk *A* on the motor shaft, so that it will

slip around and make the hole in the slotted disk *B* just large enough so that it will fit tight on the shaft. Start up your motor and then change the speed of your radial bar disk by pressing your finger against the edge of it, and at the same time look through the slotted disk. By changing the speed of the radial disk, one set of the bars will seem to be standing still, while the other set will apparently rotate. Again, when the speed is changed the two sets of bars will seem to turn in opposite directions, and sometimes the bars will take on the form of curves.

The Phantom Vases.—This is a wonderful experiment that illustrates the persistency of vision. Screw the coupling of your motor on the shaft and screw the motor in the vise, so that the shaft is vertical and pointing up. Now take half a dozen pieces of iron wire one-sixteenth inch in diameter and three inches long, and bend them into various shapes, as shown at *A* and *B* in *Fig. 110*.

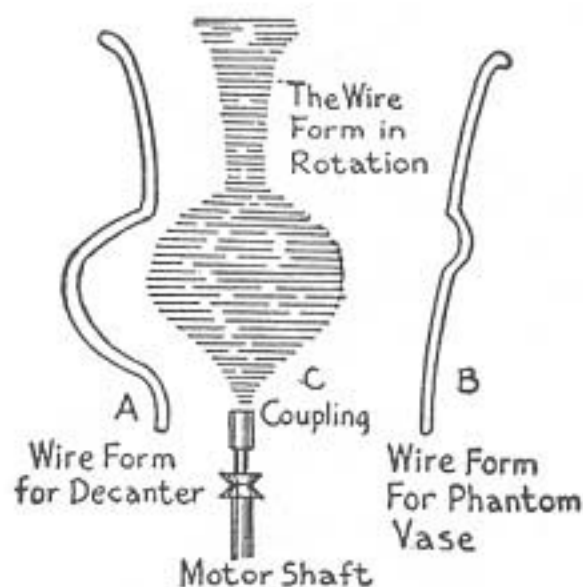


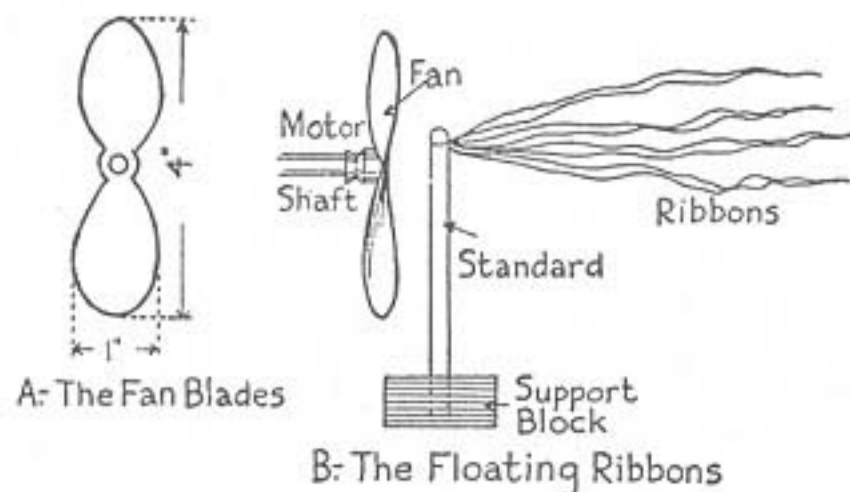
Fig. 110. The Phantom Vases.

Screw one of the bent wires in the coupling, as at *C*, and start up your motor slowly when, due to the persistency of vision, it will take on the shape of a vase, but it will be as thin as the stuff of which dreams are made. With a little experimenting you can make all manner of phantom-like objects, and the effects are often very weird.

Experiments with an Electric Fan.—*A Simple Fan.*—Make a two-bladed fan out of a piece of tin, sheet brass, or copper, as shown at *A* in *Fig. 111*, and

screw it on the shaft of your motor. Turn on the current and you will have a breeze as fresh as though it came from the North Pole.

The Floating Ribbons.—Mount a wire in a wood

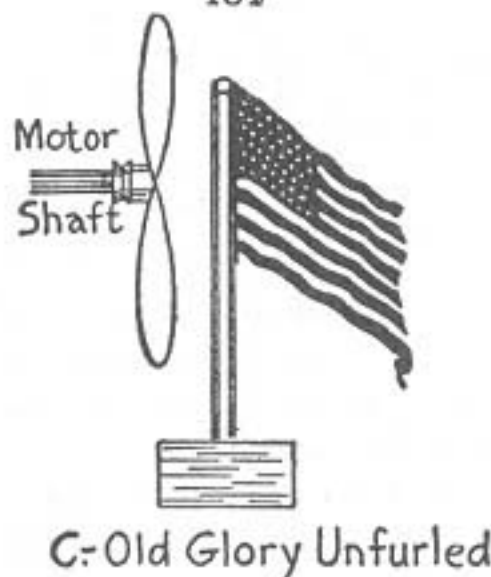


(A-B) Fig. 111. Experiments With an Electric Fan.

block and fasten three or four tissue paper ribbons about five inches long to it, as shown at B. Place it in front of the fan and start the motor running, when the breeze set up will blow the ribbons out and keep them floating in the air.

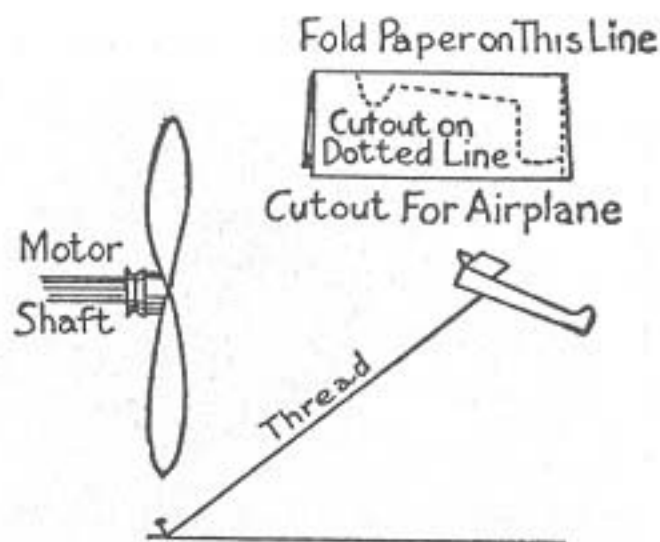
Old Glory Unfurled.—Get a little soft, silk flag about one and one-half inches long, and glue one end of it to a match; then stick the free end of the match in a hole in a block of wood, or support it otherwise, and set it in front of the fan, as shown at C. Now start your motor, when the breeze set up will make the flag wave gloriously—and long may it wave!

An Airplane in Full Flight.—This experiment makes an interesting display for a store window. Begin by making an airplane, and this you do by folding over a sheet of thin paper and cutting it out, as shown



at D; paste the folded part at the seam together and spread out the wings and the tail.

Stick one end of a silk thread about six inches long to the airplane, and fix the other end to the table with a bit of wax under the fan and in a line with the center of it, when the airplane will soar away—without getting anywhere. Besides the foregoing experiments with the fan, there are many others that you can work

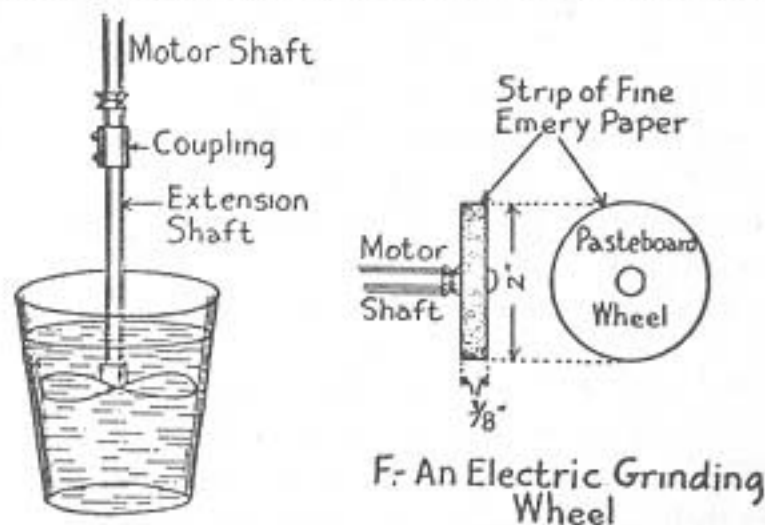


(C-D) Fig. 111. Experiments With an Electric Fan.

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up, which will not only provide amusement, but which will add to your store of information as well.

An Electric Stir-a-Bout.—This is a very useful device for stirring up a drink or beating up an egg. To make it, couple the extension shaft on to the shaft of your motor, as shown at E, and screw the fan on



E: An Electric Stir-a-bout

(E-F) Fig. 111. Experiments With an Electric Motor.

the end of it. If the fan is to go inside a tumbler, you will have to make a smaller one, say about two inches in diameter. To use the stirrer, hold the motor firmly in your hands, at the same time being careful not to touch any of the moving parts and also keep the blades of the fan from touching the sides of the glass.

An Electric Grinding Wheel.—This is also a useful device, for with it you can grind the blade of your

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knife, a pair of scissors, or any small article. To make the wheel, cut out enough disks of pasteboard about one and one-half inches in diameter to form a pile three-eighths of an inch thick, and glue them together, as shown at F. Make a hole in the center of it, the

wheel thus formed so that it will fit on the motor shaft tight. Now get a strip of fine emery paper three-eighths of an inch wide and six and one-half inches long, and glue it securely to the rim of the wheel. Put the wheel on the shaft of your motor and start it up, when you will have a small but very good little grinding wheel.

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XI

ELECTRICAL TOYS AND TRICKS

BESIDES the numerous experiments already described all through this book, there are some others that you can make which are in the nature of toys, and again others that can well come under the head of magical tricks.

SOME ELECTRICAL TOYS

The Jumping Ants.—You will remember that in Chapter V I told you how to make a jumping spring.

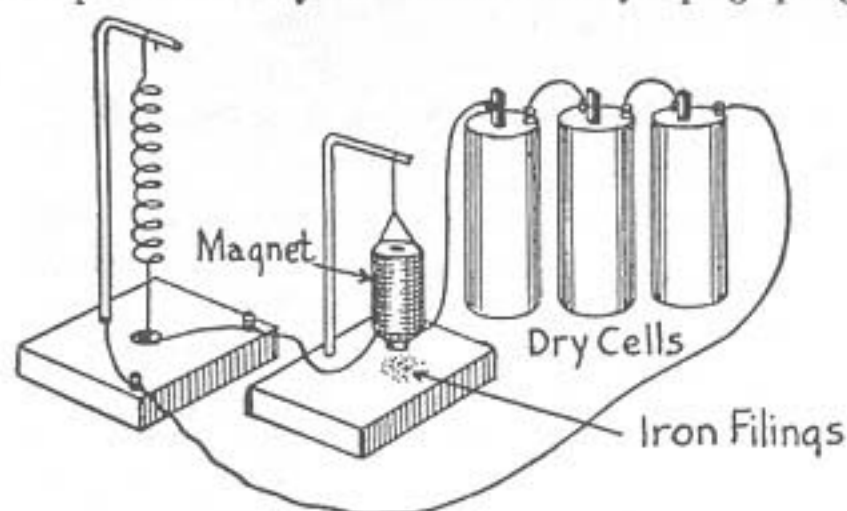


Fig. 112. The Jumping Ants.

If now you will wind up a small electro-magnet, you can make a number of amusing toys. After you have made the jumping spring, bend over a short piece of stiff wire and set it into a block of wood for a base, as shown in Fig. 112. Hang the electro-magnet on it and place a little heap of iron filings under it.

Now connect the magnet, the jumping spring, and the battery together, and every time the free end of the spring makes contact with the mercury, the current will energize the magnet, and this, in turn, will attract the iron filings to it. Then when the spring contracts and breaks the circuit, the magnet will be de-energized and the filings will drop. This action makes the filings look very much like a swarm of ants jumping up and down.

Ain't We Got Fun?—For this toy make a solenoid, that is, a sucking magnet (See Chapter V),

and set it on a wood base. Cut a little jumping-jack out of cardboard and pivot the arms and legs to the body; connect these members up with thread, so that

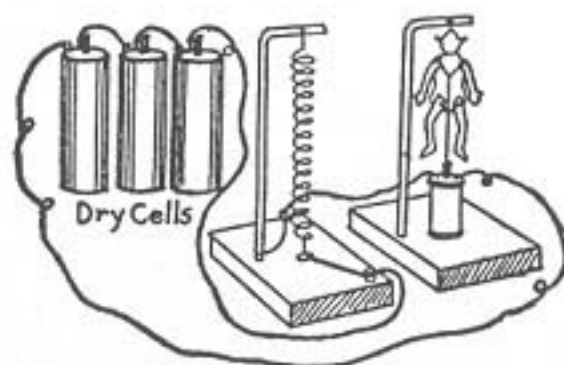


Fig. 113. Ain't We Got Fun.

when you pull the end of it that hangs down they will give a spasmodic jerk. Now hang the jumping-jack on the bent end of a brass wire support, and fasten the lower end of the thread to the end of the plunger core of the solenoid. Connect the ends of the solenoid, the posts of the jumping spring and the poles of a battery of two or three dry cells in series, as shown in Fig. 113, when the jack will jump automatically.

Mr. Jazz of Razmataz.—To make this amusing toy, cut a little head and body out of a bit of cork; then extract three stiff bristles from a hog's back (or perhaps it would be easier to get them from a hair brush), and stick them into the lower part of his anatomy at exactly equidistant points, as shown in Fig. 114. Now lay a telephone receiver flat on the table

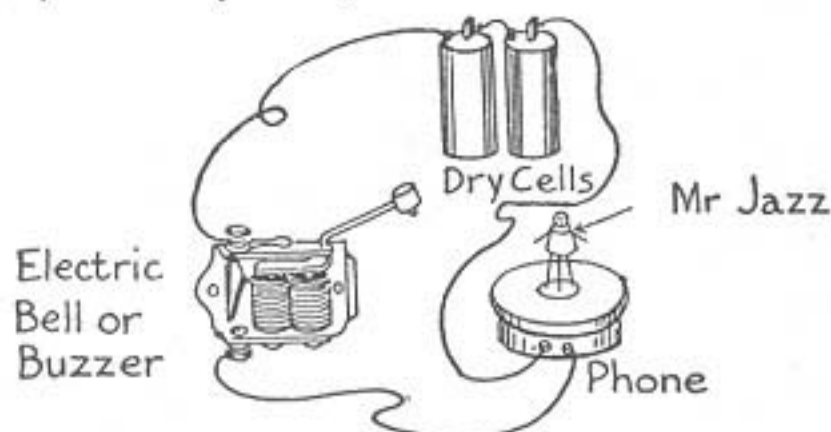


Fig. 114. Mr. Jazz of Razmataz.

and connect it, an electric bell, or buzzer, and a dry cell in series. Finally, set Mr. Jazz on the diaphragm of the telephone and the buzzer will make him jazz for all he is worth.

Mount Vesuvius in Eruption.—In Chapter X you were told how to make an electric grinding wheel. Now take this wheel and cover the rim of it with coarse emery paper and mount it on the motor shaft. Next draw a picture of Mount Vesuvius on a sheet of heavy cardboard, cut it out, and stand it up in front

of your motor, as shown in *Fig. 115*. Press a nail against the rotating emery wheel, when it will send

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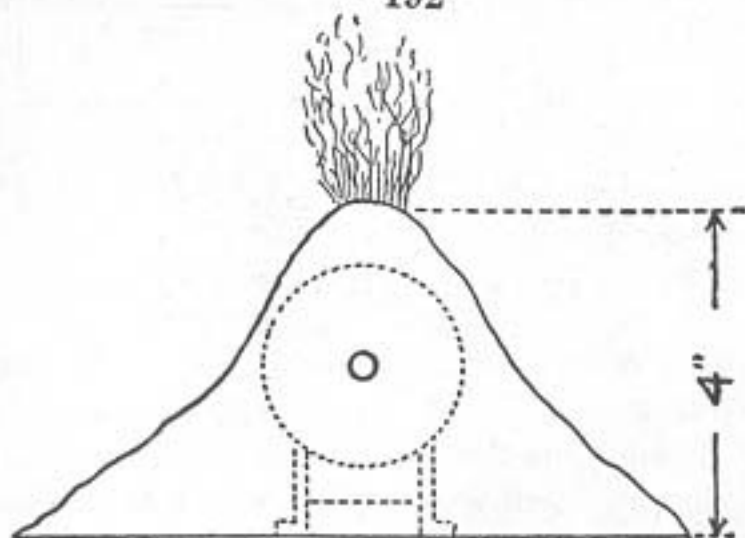
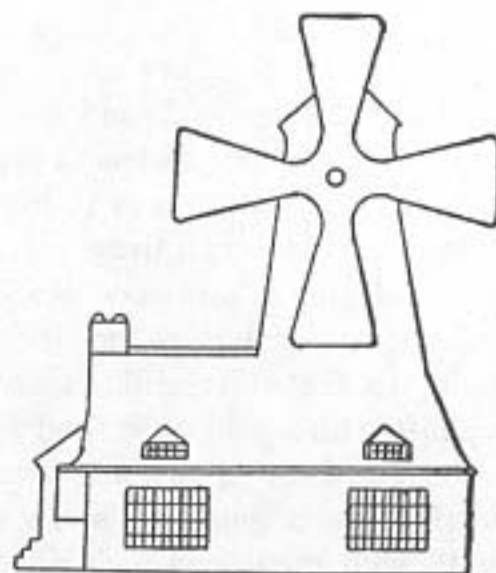
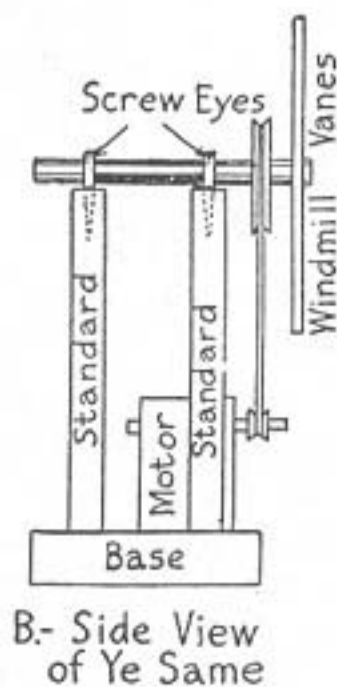
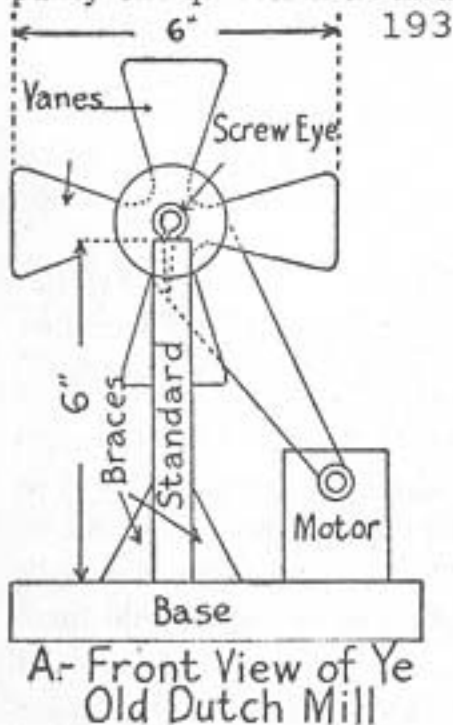


Fig. 115. Mount Vesuvius in Eruption.

out myriads of sparks. If you will make this experiment in a dark room, it will look as if Mount Vesuvius were in eruption again.

How to Make Ye Old Dutch Mill.—This is an easy toy to make and an interesting one to look at. The pictures shown at *A* and *B* in *Fig. 116* are clear enough so that you can build ye old Dutch mill from them without the slightest trouble. Get a board one-half inch thick, three and one-half inches wide, and five and one-half inches long, for the base. Take two pieces of wood, round or square, about one-half inch thick, and six inches long, for the uprights, and nail and brace them to the base one and one-half inches apart.

This done, screw two screw-eyes into the tops of the uprights and slip a piece of dowel four inches long through them for the shaft. Make a pasteboard pulley one-quarter inch thick and two inches in diam-



C- Ye Old Dutch Mill Complete

Fig. 116. How to Make Ye Old Dutch Mill.

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eter, and cut a groove in it. To make the pulley, cut out enough disks of thick pasteboard to get the required thickness, glue them together, and put a flat-iron, or other weight, on them. Cut a one-quarter inch hole in the center of it, slip it on the shaft, and glue it there.

Draw a circle six inches in diameter on a piece of cardboard, mark out four vanes on it, as shown at *A*, cut it out and glue it to the end of the shaft. Screw down your motor to the other end of the board, and belt the pulleys together with a soft string. Finally, draw a picture of ye old Dutch mill on a sheet of heavy cardboard, as shown at *C*, and glue it to the front edge of the base, when your windmill is ready to run and grind its grist of fun.

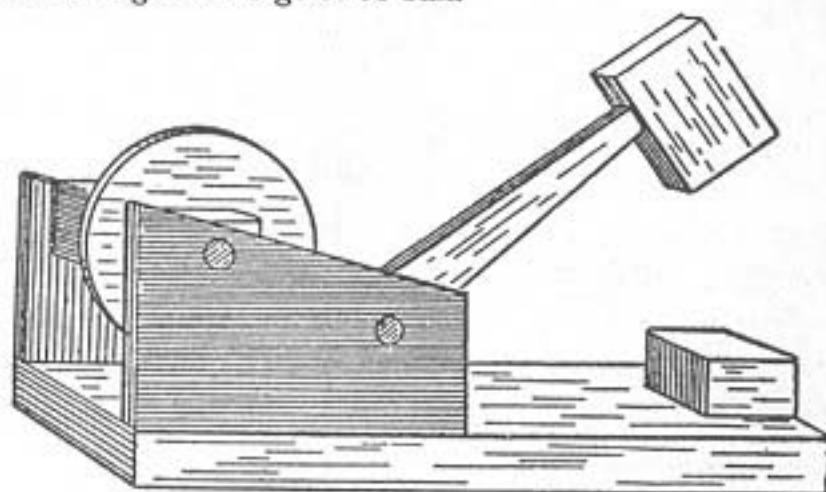


Fig. 117. A Motor Driven Trip Hammer.

How to Make a Motor-Driven Trip-Hammer.—The chief merit of this hammer is that it makes a noise. Get a board one inch thick, four inches wide, and eight and one-half inches long, for the base, and then cut out two support blocks one-half inch thick,

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one and one-half inches high at one end, two and one-half inches high at the other end, and four and one-half inches long; drill two one-sixteenth inch holes in them near the bottom, as shown at *A* in *Fig. 117*.

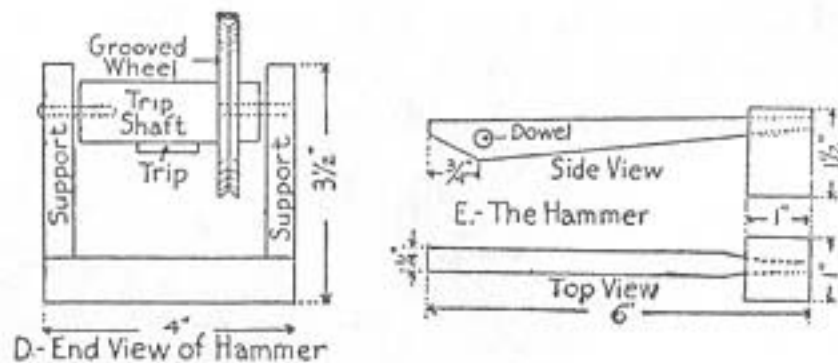
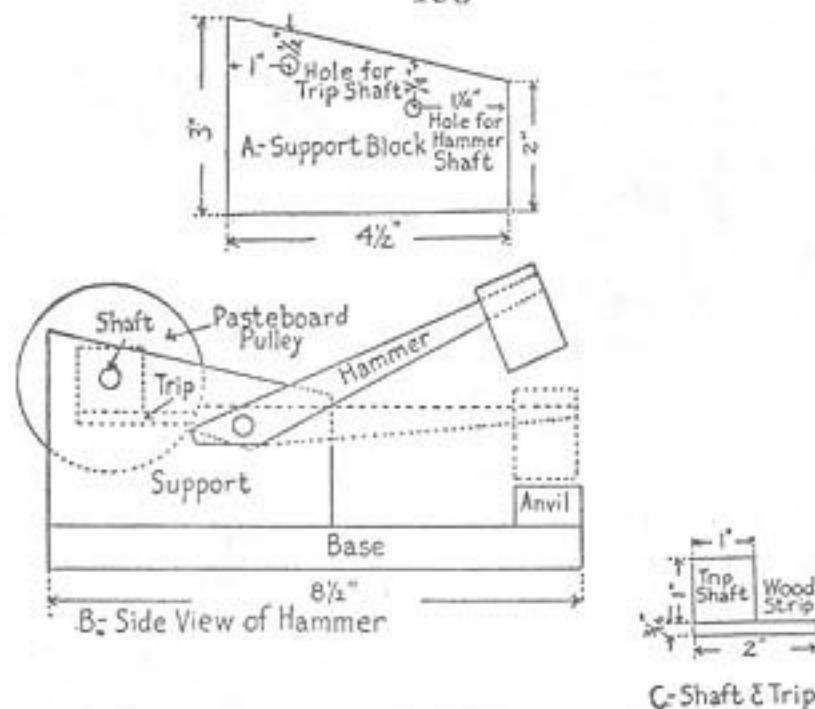
The next thing to do is to nail these supports to the base at one end and glue a hardwood block, which is called the anvil, one-half inch thick, one inch wide, and two inches long, to the other end, as shown at *B*. Now make a shaft with a trip on it, and for this use a piece of wood one inch square and two and one-quarter inches long, and glue and screw a piece of wood one-eighth inch thick, one inch wide, and two inches long, to one side of the square trip shaft, so that it projects over it, as shown at *C*.

This done, make a grooved pasteboard pulley as described in the foregoing toy, but have it three-eighths of an inch thick and three inches in diameter, and glue and screw this to one end of the shaft, as shown at *D*. Set the shaft between the upper holes in the support, push a wire nail through each hole and drive them into the ends of the shaft.

The next and last part to make is the hammer, and for this get a block of hardwood one inch thick and one and one-half inches long, and make a tapering hole through it near the top, as shown at *E*. Cut out a wood lever one-half inch thick, one-half inch wide at the point where the pin goes through it, and taper it at both ends, as shown at *E*. Drill a one-quarter inch hole through the lever three-quarters of an inch from one end, and glue the other end into the hammer block.

Now push a dowel four and one-half inches long,

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(A-E) Fig. 117. A Motor Driven Trip Hammer.

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through the other hole in the support, slip the hammer lever on to the dowel, and glue it to the middle of the latter. Finally, run the dowel through the other hole in the support, when your trip-hammer will look like *G*. Belt the motor to your trip-hammer, turn on the current, and you will have a regular Robin Hood anvil chorus.

SOME ELECTRICAL TRICKS

The Electrified Papers.—While this is not strictly a trick, I once knew a magician who used it as



Fig. 118. The Electrified Papers.

an experiment leading up to the power of mind over matter, and it is also one that makes an audience laugh for the same reason that a girl laughs when she has her picture taken.

Tear up a sheet of newspaper into strips, as described under the sub-caption of "The Electrified Papers" in Chapter I. Now go among the audience,

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or a room full of people, and as you electrify each strip by rubbing it with your finger nails, as shown at *A* in *Fig. 1* (See Chapter I), place it on the face of one of the spectators, as shown in *Fig. 118*, when it will be attracted to it by electrostatic induction and held there by electric attraction.

The Light and Heavy Box.—About fifty years

ago there lived a famous French magician named Robert-Houdin, and he was sent to Africa to tame the fierce Algerians with his tricks. The one they could not understand was his light and heavy box. This was a box with a pair of handles in the ends and light

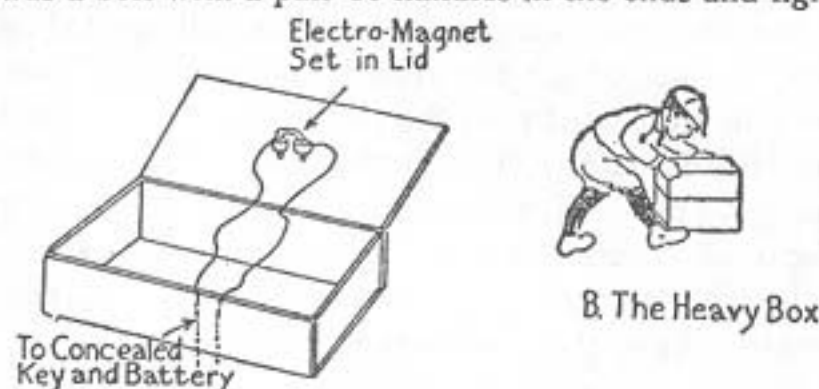


Fig. 119. The Light and Heavy Box.

enough so that a boy could easily lift it. But when the great magician commanded it to get heavy, the strongest Algerian tribesman could not budge it.

You can make one on a small scale and mystify your friends. Begin by boring two holes in the top of a cigar box and fix an electro-magnet on it so that the ends of the poles are flush with the top of the box, and then paste a piece of paper over the surface to keep them from showing, as in Fig. 119. Now run two

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wires out of the box and to your key and battery, which must be concealed.

Nail the box to the floor or to the top of an old table, and nail down the lid. This done, take another cigar box and fix a piece of thin sheet iron on the bottom of it, and cover this over with paper. Set this box on the top of the other one and let a spectator pick it up, which he can easily do as long as the current is off; then have your assistant, who is concealed, close the key and the spectator will find that the box is now quite heavy, as shown at B.

The Spirit Whispering Box.—"I can call spirits from the vasty deep." "Why, so can I, or so can any man, but will they come when you do call for them?" Shakespeare makes two of his famous characters say. Well, here is a box that is a medium through which the spirits will come when you do call for them.

Make a coil about one foot in diameter of No. 18 double-cotton-covered magnet wire, and have twenty turns in it. Lay this coil in the drawer of a table and connect a pair of wires to the ends of it; run them out and into another room so that they cannot be seen, and connect them to a telephone transmitter (See Chapter VII) and a battery.

Now wind up a coil of twenty-five turns of No. 24

wire, and make this one just large enough to go around the inside of a cigar box. Bore a one-half inch hole in the top of the box and fix a telephone receiver to it, so that the opening of it is exactly over the hole in the box.

Last of all, connect the coil in the box to the telephone receiver, and nail or screw the lid of the box

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down tight. Give the box to a spectator to hold to his ear, and then have your pal talk into the transmitter in the other room, when the listener will hear voices from the other world—that is, he will if he believes so. The whole scheme is shown in Fig. 120.

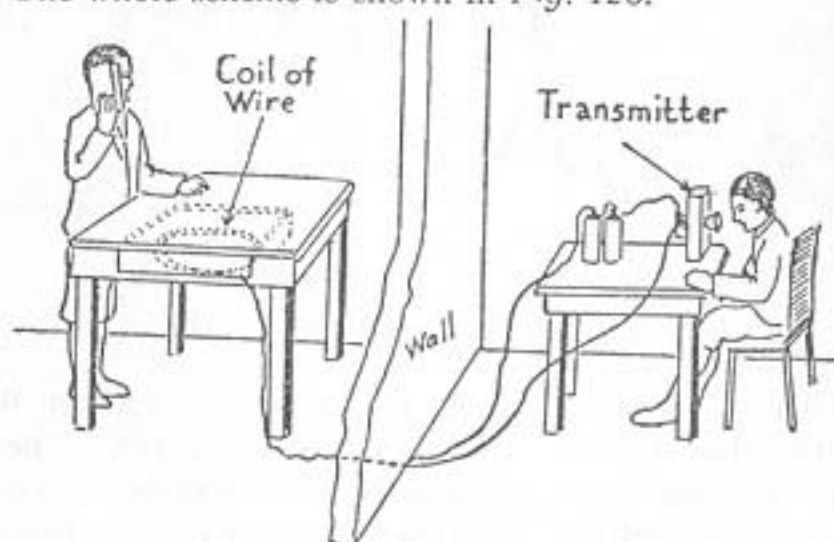


Fig. 120. The Spirit Whispering Box.

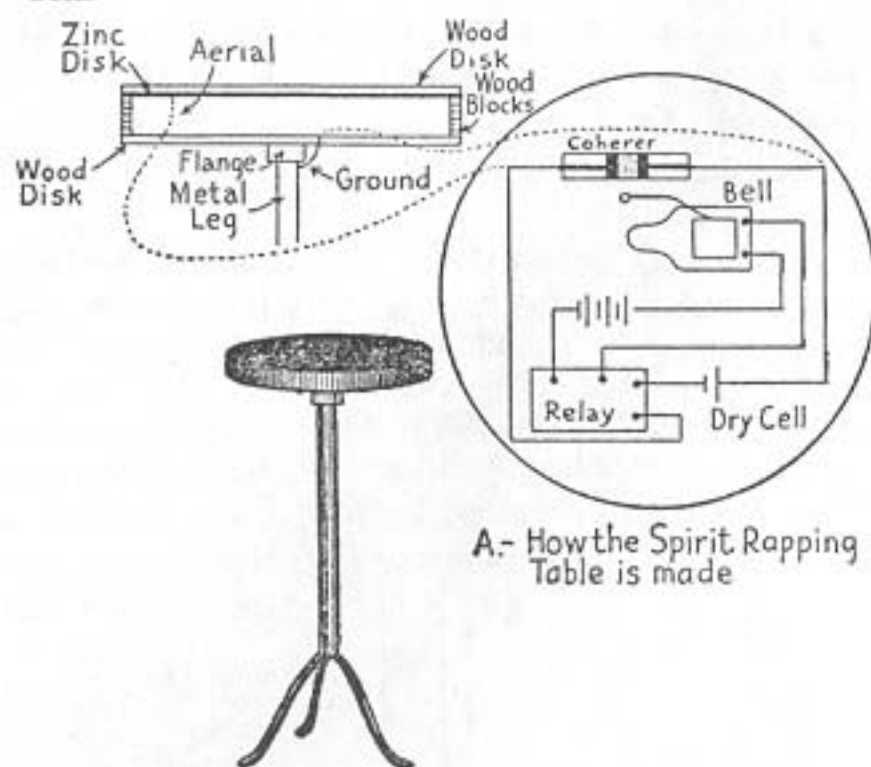
Instead of using a box to listen-in to, you can put the coil and receiver in a teakettle, when voices will be heard coming from the spout, and instead of having a coil of wire in the table you can have a big one under the floor of the room. All of these marvellous effects are, of course, due to mutual induction between the two coils.

The Spirit Rapping Table.—This is the last word in spirit table-rapping, and the effect is startling, to say the least. You carry a small table formed of a single leg, with three extension feet, through the audience. You now ask questions of the dear departed, or have the spectators do so, when the table

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will rap out the answers—*three* for "yes," *one* for "no," and *two* for "I don't understand," or "I will have to look it up in the encyclopædia," which is in accordance with the most approved spiritualistic code; and, to cap the climax, it will continue to rap out answers when it is held by any of the spectators.

Yes, you have guessed it—the table is worked by wireless, and here is the *modus operandi* of it. Get a small table with an iron or brass leg, if possible. Now make a wireless coherer receiving set, as described in



A.- How the Spirit Rapping Table is made

B.- The Table Ready to Use

Fig. 121. The Spirit Rapping Table.

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Chapter XIX, but without the sounder, and mount it in a hollow table top, as shown at A in Fig. 121. This you can easily make by sawing out two disks of one-half inch thick wood for the top, and twelve or fourteen inches in diameter. Fix a flange to one of them so that it can be screwed to the top of the metal leg; on this disk mount the receiving set and connect one plug of the coherer with the metal leg for the ground.

Now fasten a sheet of zinc to one side of the other disk and connect the other plug of the coherer to it. Next, mount this disk on top of the receiving set and keep the zinc plate at least one-quarter inch away from the instruments; this you can do by separating the two disks with half a dozen wood blocks one-half inch square and about two inches high; this will make the total thickness of the table three inches. Cut a strip of heavy cardboard three inches wide and three and one-quarter feet long, and tack it around the disks to cover the space between them. Finally, paint the table top a dead black, and your table is ready to couple this world with the next. It is shown ready to use at B.

Set up the spark coil transmitter, which is also described in Chapter XIX, close to where you want to use the table, but it must not only be concealed from sight, but the noise of the spark must not be heard. Run the aerial wire from one side of the spark gap up the wall and connect the free end of it with a zinc, or copper, plate, twelve inches on the sides, and this should be suspended by a porcelain insulator. Then

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run a wire from the other side of the spark gap to a like zinc, or copper, plate, and let it rest on the floor.

Now when you hold the table in your hand and your chum presses the key down as he would to make a dot if he were telegraphing, the receiver will respond and the hammer of the electric bell will give forth a very uncanny rap as it taps the glass tube, and, of course, it will answer any question that you or the spectators may put to it. The fact that you can let any spectator hold the table and still get the physical manifestations of spirit power on the plane of sound, i. e., raps, is very mystifying to those who are not "in the know."

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XII

ELECTRIC LIGHT, HEAT AND POWER

KNOWING now how generators are made and work and how practical ones, by which are meant those that are large enough to do useful work, are driven by engines and other prime movers, you are ready to take up the alluring subject of household electricity. If your home is already wired and you have current supplied from a central station, you won't have to worry about installing a generator, and you can have all the light, heat and power you want at any time and place you want it.

ELECTRIC LAMPS AND LIGHTING

There are several kinds of electric lamps in use, but the two chief types are, (1) *incandescent lamps*, and (2) *arc lamps*. The former are generally used for internal illumination, and the latter for external illumination, but sometimes it is found convenient to reverse the foregoing order, depending on conditions and the kind and extent of lighting that is needed.

Incandescent Lamps.—An incandescent lamp is one in which a filament having a high resistance is heated white-hot, that is, to incandescence. The incandescent lamp was invented by Edison in 1879, and in his first practical lamp he used a filament made of a hair-like strip of bamboo; this was changed into

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carbon by heating it, and it was then sealed in a glass bulb and the air exhausted from it.

As time moved on great improvements were made in the lamps, and chief among these was the substitution of pure cellulose for the bamboo fiber. Now the woody fiber of all plants is formed of cellulose, and this compound in turn is formed of six atoms of

carbon, ten atoms of hydrogen, and five atoms of oxygen. Cotton is practically pure cellulose, and when it (the cotton) is treated with nitric acid, gun-cotton results. The gun-cotton is now dissolved in ether and alcohol, when a viscous fluid called collodion is formed.

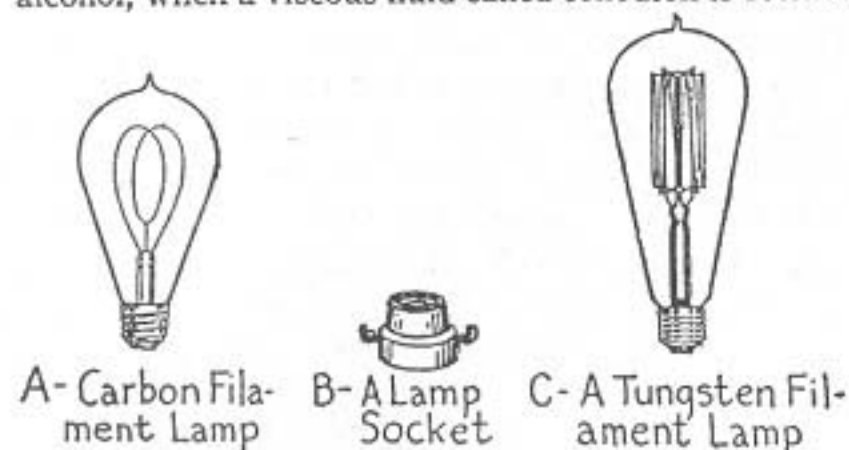


Fig. 122. Kinds of Incandescent Lamps.

The collodion is then forced through nozzle-like holes made in sheets of steel, and from this they pass through a bath of alcohol, which hardens them. The threads thus obtained are now laid carefully into graphite crucibles, which are brought to a high temperature in a vacuum, when only pure carbon remains. The threads are then cut up into filaments, and the ends of these are joined to a pair of wires, which are

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sealed in the base of a glass bulb. The final operation is to exhaust the air from the bulb when the latter is sealed off and the lamp is ready to use, as shown at A in Fig. 122.

A hollow metal screw plug is cemented to the bottom of each lamp, and one of the terminal wires of the filament is soldered to the screw plug, and the other terminal wire is soldered to a brass disk, which is secured in and to but insulated from the bottom of the screw. A metal screw socket which may be attached to an electric cord or secured to the wall or an electric fixture also has a metal base fixed in but insulated from it, as at B.

One of the service wires that carries the current from the generator, or storage battery, is connected with the metal disk, and the other wire with the metal screw. Now, when you screw the lamp into the socket the male and female screws and the metal disks will make contact, when the current will be conducted through them to the filament of the lamp.

The More Recent Tungsten Lamps.—Tungsten is one of the rare metals of the earth and it was found, several years ago, that if the filament of an incandescent lamp were made of it, it would give a far whiter

and brighter light with a smaller consumption of current than where a carbon filament was used. So in these days the carbon filament lamp is seldom seen, and when it is, it is conspicuous for its feeble light and yellow color.

When tungsten is used for the filament, it is drawn down about as fine as a horsehair. It is then wound in a staggered form on a glass and wire support, which

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is finally sealed into a bulb, as in the case of the carbon filament previously explained. A tungsten lamp is shown at C. The bulb is then exhausted and left a vacuum, or else it is filled with nitrogen gas. Miniature tungsten lamps of various candle power are used for many different purposes, and among these may be mentioned flash-lamps, Christmas tree lamps, and motor-car lamps.

What Candle Power Means.—The candle power of any lamp is that which is equal in strength to one made by a standard candle, and this latter, in turn, is one that will give a light equal to a candle which will burn 120 grains of spermaceti wax per hour. The candle power of a light can easily be found by comparing it with that of a standard candle, and this is done with a simple apparatus called a *photometer*.¹

¹ Any text book on *Light* will give you an explanation of how this is made and works.

The light an incandescent lamp will give depends chiefly on (1) the *material* of which the filament is made, (2) on the amount of *current* (which is measured in amperes²) that flows through the filament, and (3) the *pressure* (which is measured in volts) that forces the current through it. A *watt* is equal to the *amperes multiplied by the volts*, and it takes about three watts per candle power to raise the carbon filament of an incandescent lamp to brilliancy, while it takes only one watt per candle power to raise the filament of a tungsten lamp to brilliancy.

² See the next chapter.

How to Connect Up Lamps.—All incandescent lamps are made to be used with a given voltage, and

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this for ordinary lighting purposes is either 110 volts or 220 volts. As the voltage of a lighting circuit is constant and the current is variable, the lamps and other apparatus are connected across the service wires, or in *parallel*, as it is called, as shown in the diagram in Fig. 123, when each lamp, heating appliance or motor takes the necessary amount of current to operate it.

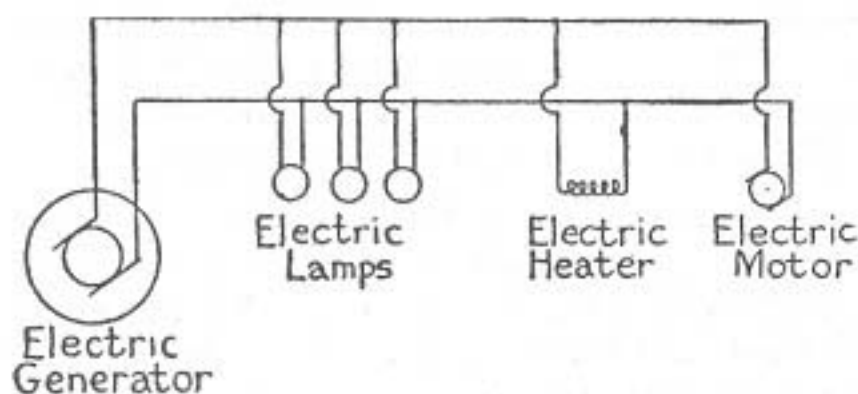


Fig. 123. How Lamps, Heaters and Motors Are Connected Up in Parallel.

Connecting the lamps and other appliances in *parallel* has several advantages over connecting them in *series*. Chief among these are, (a) if a lamp or other piece of apparatus burns out, it does not break the circuit, or (b) if there is a variation in the amount of current used by a piece of apparatus, the other lamps and other appliances are not appreciably affected.

About the Electric Arc Lamp.—In the year of 1800 when the electric battery had been pretty well developed, Sir Humphry Davy, a British scientist, found that by connecting the electrodes of one with a couple of pieces of charcoal, then holding the latter in contact and drawing them apart a little, a light that proportionately rivalled the brilliancy of the sun was produced; and it was thus that the electric arc light was born.

A current having a pressure of at least forty volts must be used to produce the arc, and if you will use the following experimental lamp to strike the arc with and then examine it through a piece of red glass; to protect your eyes, you will observe that the current as it flows across the air-gap between the ends of the carbons takes on the curve of an arc and that it is of dazzling brightness. The + or *positive electrode* of the battery should always be connected with the upper carbon and the — or *negative electrode* with the lower carbon.

This is because the lower end of the + or positive carbon becomes concave as it burns away, and as this cavity is heated to incandescence the light of it is thrown down just as though there was a reflector back of it. Moreover, the upper carbon burns away about two-thirds as fast as the lower carbon, and the end of the latter takes on a blunt form.

A Simple Experimental Arc Lamp.—To make the simplest kind of an arc lamp that can be used for experimental work, cut out a base-board one-half inch thick and four inches on the sides, as shown in Fig. 124. Now drill a one-quarter inch hole in the center

of it, a three-eighths of an inch hole one and one-quarter inches in front of it, and a one-eighth inch hole in the two front corners.

Next, cut off a piece of brass rod five and one-half inches long for the support, file off one of the ends to a fairly sharp edge, and then set the other end into the center hole in the block, so that it will remain in a rigidly fixed vertical position. This done, cut off two pieces of thin brass tubing three-eighths of an inch in

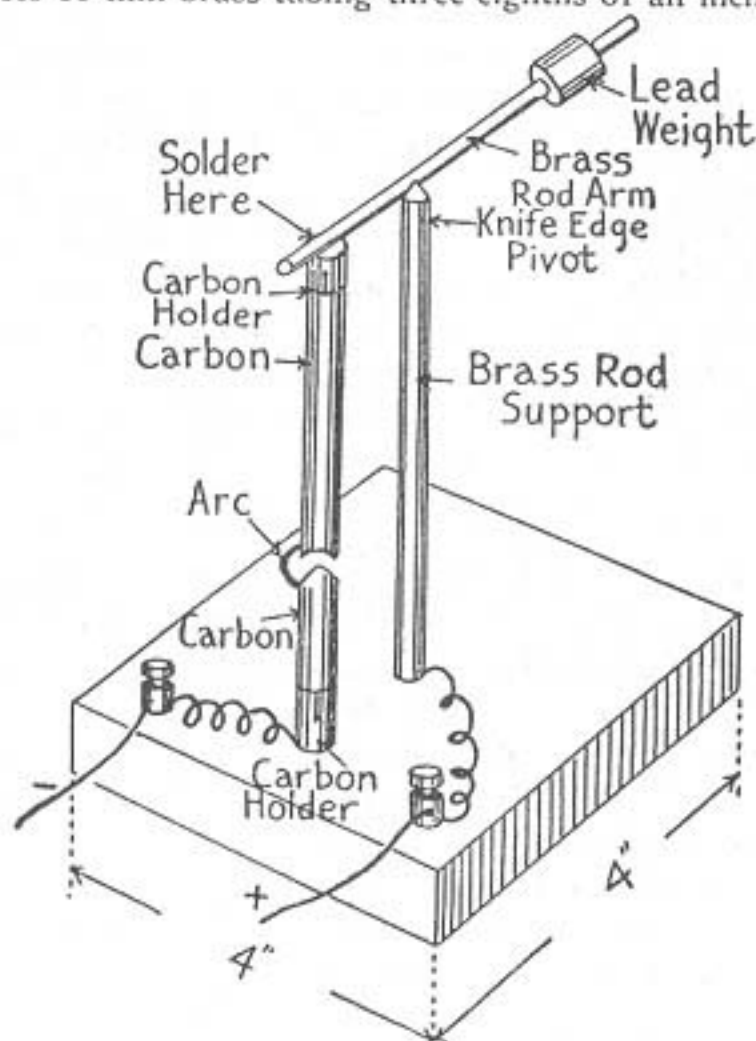


Fig. 124. A Simple Experimental Arc Lamp.

diameter (outside measurement) and one inch long, and cut a couple of slits half-way down in each one.

Push one of these carbon holders into the large hole in the base and solder the end of a brass rod one-eighth inch in diameter and four and one-half inches long, in which you have filed a V notch, one and one-half inches from one end, to the top of the other carbon holder. Make a weight of a piece of lead one-half inch in diameter and five-eighths of an inch long, and drill a three-sixteenths of an inch hole through the center of it lengthwise, when you can slip it over the brass arm.

Finally, screw two binding posts into the front holes on the base; fix a piece of heavy copper wire to each one, and then solder the free end of one of them to

the carbon holder in the base and the free end of the other one to the lower end of the support rod. Push a carbon rod three-eighths of an inch in diameter and about one and one-half inches long into the lower carbon holder, and a carbon rod about three inches long into the upper holder. Now set the rod arm on the knife edge of the support and see that the carbons are exactly in a line; then adjust the weight so that the rod arm exactly balances, when your experimental arc lamp is complete.

All you need to do now is to connect the binding post which makes connection with the lower carbon, to one end of a battery which gives a current of forty volts or over, or better, to a generator or a lighting circuit which gives a 110-volt current. When you use either of the latter sources of current, you must have a resistance in circuit to cut down the current to the required strength and then strike the arc.

How a Regular Arc Lamp is Made.—In a commercial arc lamp the upper carbon is fed automatically as it burns off, so that the length of the arc always

remains the same. When the current is turned on, the upper carbon is raised by means of an electromagnet and fed down by gravity, all of which is controlled by a *clutch*. This device is formed of a brass ring whose inside diameter is just a shade larger than the rod which holds the upper carbon, and it is pivoted to another rod that ends in a core of soft iron.

In the top of the lamp is a solenoid, or sucking magnet, and the core of soft iron extends into the hole of the solenoid, as shown in the diagrams in *Fig. 125*.

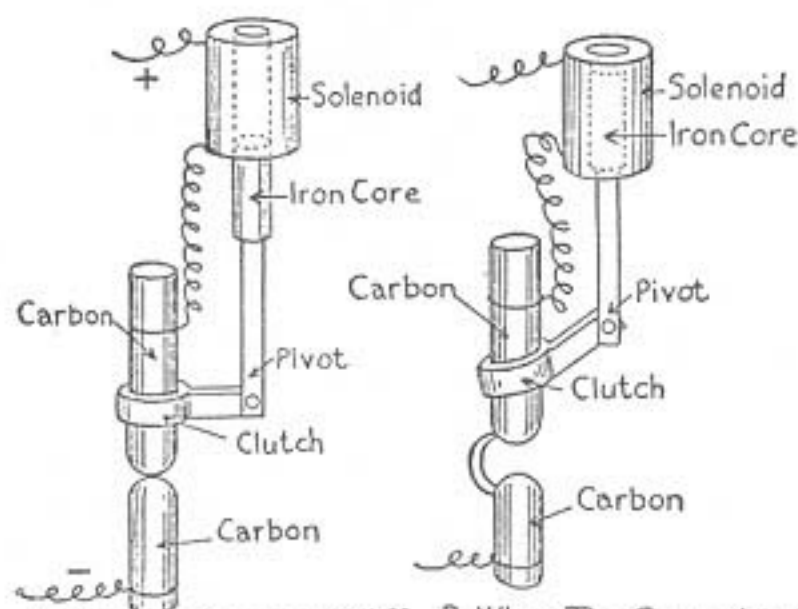


Fig. 125. How a Standard Arc Lamp is Made.

One terminal of the solenoid is connected to the + or *positive* wire of the generator or service wires, and

the other terminal of it is connected to the upper carbon, while the lower carbon is connected with the — or *negative* wire of the generator or service wire.

Now, when the current flows through the solenoid, ²¹⁶ it sucks up the core, and as the clutch is pivoted to the latter its weight holds the free end down, and as the core keeps on moving up the clutch grips the carbon rod, when it also moves on up with the core until the carbons are far enough apart to strike the arc.

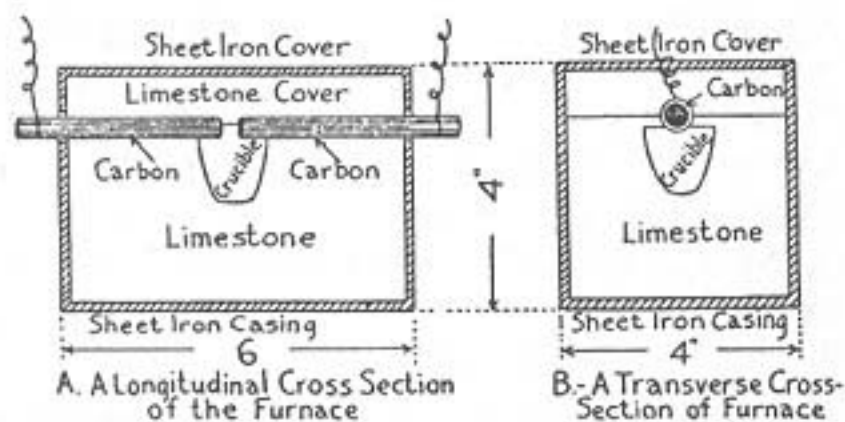
As the carbons burn away the arc grows longer and, hence, the resistance of it becomes greater; the consequence is that less current flows through the solenoid and its magnetic force gets weaker. The core then slips down and this releases the grip that the clutch has on the carbon rod a little, when the latter moves down until the arc is short enough so that more current again flows through the circuit. In a commercial arc lamp there are other additions and refinements, but they all work on the above principle.

How to Make an Experimental Electric Furnace.—In these days of creative chemistry when so many new compounds are being produced by the electric arc and so much that is yet unheard of remains to be discovered, you should build an electric furnace, if possible, and do a little experimenting on your own hook. Fortunately, the cost of making an electric furnace is very small and its construction is exceedingly simple.

The temperature of an electric arc is in the neighborhood of 7,000 degrees Fahrenheit, and this is twice as high as is needed to melt platinum, so, obviously, it is easy to melt any of the ordinary metals with it. The first electric furnace was made by Dr. Robert Hare, a chemist of the University of Pennsylvania,

²¹⁷ shortly after Davy produced the arc light, and with it he "changed charcoal into graphite, separated phosphorus and obtained the metal calcium from their respective compounds."

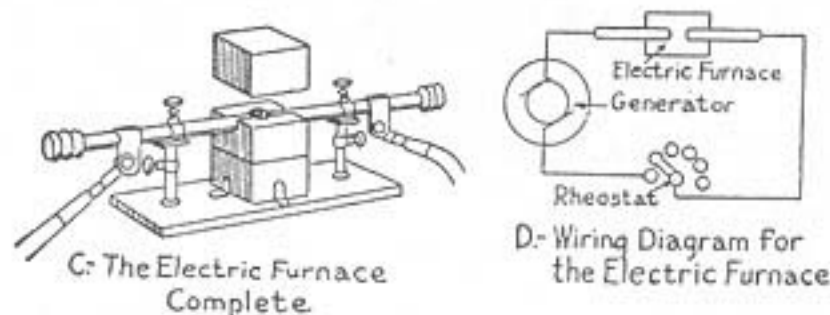
To make a small electric furnace, in which you can melt an ounce or so of any of the ordinary metals, make a box, or casing, of sheet iron about four inches high, four inches wide, and six inches long, with a cover to fit it. Get a block of limestone, or calcium carbonate, to give it its chemical name, three inches high, four inches wide and six inches long. Cut a conical hole in the top of the block just large enough so that a graphite crucible one inch in diameter and about one inch deep will set into it; and cut out a half-round groove three-eighths of an inch across length-



(A-B) Fig. 126. The Experimental Electric Furnace.

wise in the top of the limestone block, so that the carbons will lay in them snugly.

Next make a limestone cover about one inch thick, four inches wide, and six inches long, and cut a half-round groove three-eighths of an inch across in one side of it, so that when the carbons are laid in the lower groove and the cover is put on the grooves, it will fit over them. Two cross-sectional views of the electric furnace are shown at A and B in Fig. 126, and the furnace complete at C. Finally, place whatever metal or substance you want to melt or heat to a high temperature in the crucible and connect the



(C-D) Fig. 126. The Experimental Electric Furnace.

ends of the carbon to a 110-volt generator or power circuit with a rheostat, which is a variable resistance, in circuit as shown at D, and turn on the current.

About Electric Heating Appliances.—When a large amount of current is made to flow through a wire too small to carry it, the latter gets hot. This is because the wire has what is called *resistance*, which opposes the flow of the current. It is this principle that is made use of not only in heating the filaments of incandescent lamps, but in all other heating appliances, such as curling irons, toasters, percolators, flatirons, etc.

For heating purposes a special alloy wire or strip is generally used that has a high resistance. To make a heating unit for an electric radiator, the resistance

wire is wound on a spool, or form, of soapstone,

porcelain, slate, mica, or other heat-resisting insulator, as shown at A in Fig. 127. An insulator of this kind

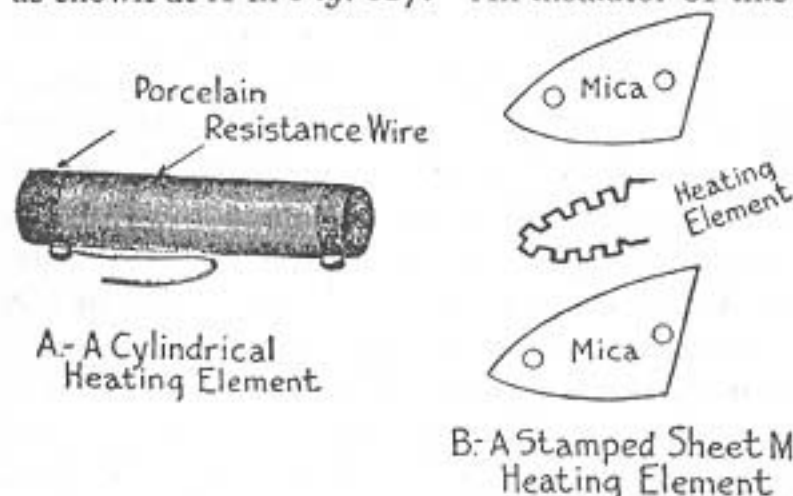


Fig. 127. Kinds of Heating Elements.

has a spiral groove in it, so that the turns of wire when wound on it will lie closely together, and yet not touch each other. A heating unit for a flatiron is made by punching a zigzag strip out of a thin sheet of high resistance alloy, as shown at B, and placing this between two sheets of mica, when the element thus formed is set into the shell of the iron and the whole is then screwed together.

About Using Electric Power.—If your house is supplied with 110-volt direct or alternating current, you have the power at hand for doing all sorts of work from running a sewing machine to driving a wood saw. Motors are made especially to be used with direct or alternating current of any horse-power or fractional horse-power you want.

For general utility work around a house or a farm, a small portable motor mounted on a tripod, as shown in Fig. 128, can be had. This can be easily moved

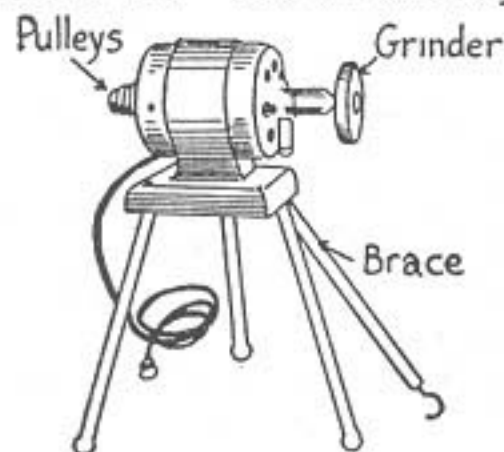


Fig. 128. A Portable Motor for Home Use.

about and connected to the lighting circuit, and the pulley can be belted to any machine you want to run.

It is easy to wire a house for electric light, heat and power, but it is hard to wire it and do a good job, especially after a house is already built. There are two ways to wire a house, and these are to use (1) *exposed* wiring, or (2) *concealed* wiring. By exposed wiring is meant that the wires are run on the surface of the walls and ceilings, and this is easy to do but not very presentable.

The time to wire a house is, of course, when it is in the process of building, for then the wires can be run between the walls and the ceilings and floors without any trouble. Where a house is already built, it is a difficult thing to *snake* the wires between walls or flooring, although it can be successfully done. To hire such a job done is expensive, hence where a house is already built and it is to be wired, the simpler and cheaper expedient of using exposed wiring is often followed.

The First Things to Do.—The first things to do when you are going to wire your house are (1) get a copy of (a) the "List of Electrical Fittings" and a copy of (b) "The National Electric Code," of the Board of Fire Underwriters; (2) get catalogs from one or more electrical supply houses which will give you the prices and other data concerning the fittings you need; (3) estimate the amount of wire and

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fittings you will require; (4) order the wire and fittings the estimate calls for, and (5) buy an electrician's kit of tools.

The National Board of Fire Underwriters is an organization whose chief office is located at 135 William Street, New York City, and whose business it is to see that all of the wiring which is done and fixtures that are made and installed are in accordance with certain rules and regulations. This is done for the benefit of the various fire insurance companies, so that the fire hazard will be reduced to as small a value as possible. There is an office in nearly every city.

The *List of Electrical Fittings* gives a list of various fixtures made by the different manufacturers, which the National Board of Fire Underwriters approves of as conforming to their rules of safety, and as these are usually just as cheap as those that have not been approved, it is good policy to use them.

The *National Electrical Code* gives the rules and regulations that have been laid down for the design and construction of safe electrical fittings; and it also gives information as to how a job must be done in order to meet the Fire Underwriters' requirements.

A copy of the Code and the "List of Electrical Fittings" will be sent to you free of charge by the National Board of Fire Underwriters, or you can, probably, get a copy of each one from any fire insurance agent in your community.

In nearly every city of any size there is a dealer in electrical supplies, and it is always the better way to buy at home, if possible.

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To estimate the amount of wire and the fittings you will need, you must first find out how many lamps, switches and fuses you want to use and decide on whether you want the wiring to be concealed or open. If the house is already built, it is easy to go over it room by room and decide where the lamps and switches shall be placed, and with a long, flexible rule or a tape measure determine the length of wire you need.

If the house is to be built, you can take the architect's plans, and these will either have the positions of the lamp fixtures marked on them, or if not, you can mark them on, with the advice of every one in the family, of course. And then with a rule you can measure off the length of wire you need. This part of the job must be done very carefully, or you will find that you have either bought too much wire and too many fixtures, or else that you have bought too little. In the first case you will waste money, and in the second you will waste time, besides the inconvenience you will be put to. So the better way is to make all of your measurements and calculations with care and nicety, and so obviate the useless expense and trouble.

While buying your wire and fixtures, you should also get the necessary tools to do the wiring, and these will be described presently. Then there are sev-

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eral other small articles you must have, and be sure to get these before you start to work.

About Wiring and Wires.—After you have wired a house, you must inform The National Board of Fire Underwriters, and they will send a man to inspect it, and if you have conformed to their rules and regulations he will pass it and give you a permit to turn on the current. First of all, there are two kinds of wiring, and these are (1) *outdoor* wiring and (2) *indoor* wiring. You will probably have little need to do any of the first kind, unless you want to run a line from the house to the garage or between other near-by buildings.

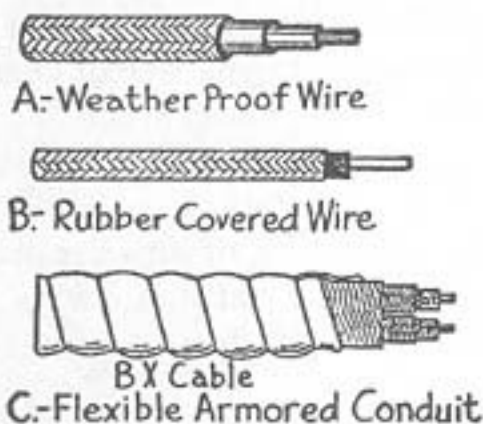


Fig. 129. Kinds of Wire.

For outdoor lines, that is, lines exposed to the weather, you must use what is known as *approved weather-proof wire*, and this must not be smaller than No. 14 gauge. While this kind of wire will stand up under the weather, it is not fire-proof and, hence, should not be used for inside work. Weather-proof wire is made by covering the wire with three braided layers of cotton, and these are then impregnated with

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a weather resisting compound. It is shown at A in Fig. 129.

For indoor work, where the wiring is exposed, or open wiring, as it is called, the wires must be either (a) supported by porcelain cleats or *porcelain knobs*, or (b) they must be run in the grooves of wood or metal molding. In either case the same kind of wire is used, namely, *approved rubber covered wire*. This kind of wire is tinned first and then covered with a slow-burning rubber compound. Outside of this is a covering of cotton yarn braid, and this is treated with a wax compound that has a high ignition point. It is shown at B. If there are not too many lamps, No. 14 wire will be large enough.

Finally, where the wiring is *concealed*, that is, run between the walls, floors and ceilings, it must be further protected by a metal sheathing. This is usually done by wrapping a heavy strip of metal spirally around it, when it is known as *flexible armored conduit*. It is pictured at C.

The Fittings You Need.—Besides the above wire, you will need the following different fittings, and the accompanying cuts show what most of them look like: *For Open Wiring:* Use *split porcelain cleats*, as shown at A in Fig. 130, or *split porcelain knobs*, as shown at B. These insulators are screwed to the studding of the walls or beams between the ceilings and floors, and they form the supports for holding the wire taut and also to keep it away from the surface of the ceiling or walls.

The insulators should be spaced from *one to three* feet apart, except where the wires turn a corner and

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then three of them should be placed close together in a radial arc, as shown at C. Before they are screwed up tight, the wires are slipped into the groove, when the screw is driven in and the wire will be held tight in place. A *porcelain bushing* (See D) is used wherever it may be necessary to run a wire through a wall.

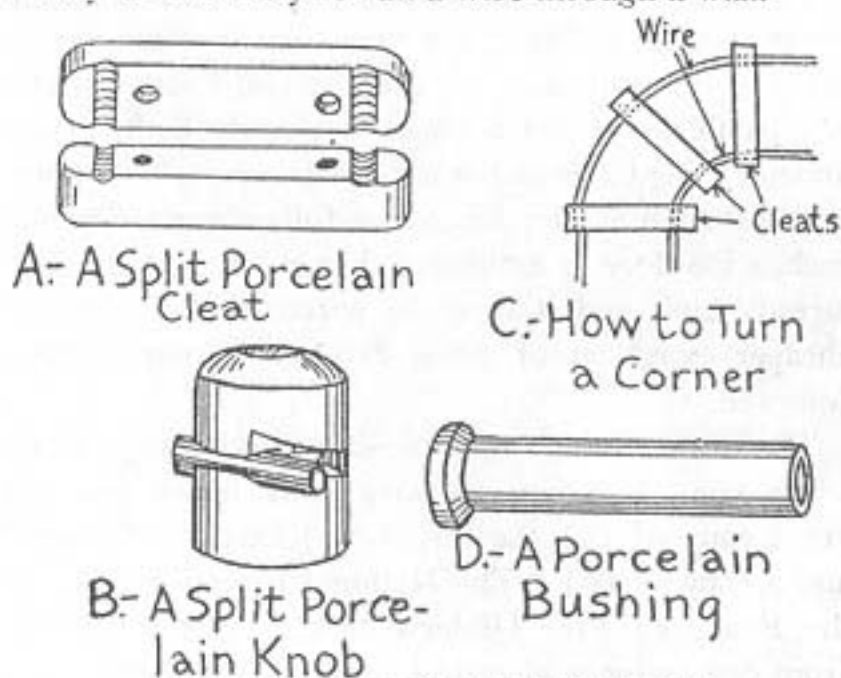


Fig. 130. Kinds of Porcelain Insulators.

Lamp holders are of two kinds, and these are (1) *receptacles*, or fixed holders, as shown at A in Fig. 131, and (2) *sockets*, or drop holders, as shown at B.

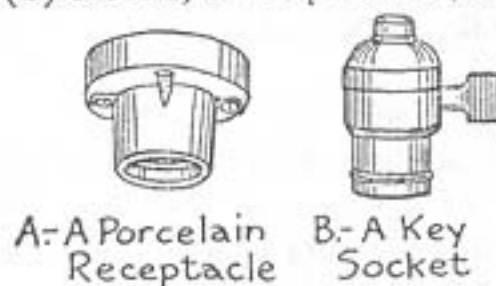


Fig. 131. Kinds of Lamp Sockets.

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There are three kinds of switches used for turning on and off the current. The first is a *double-pole, single-throw switch*, as shown at A in Fig. 132. It

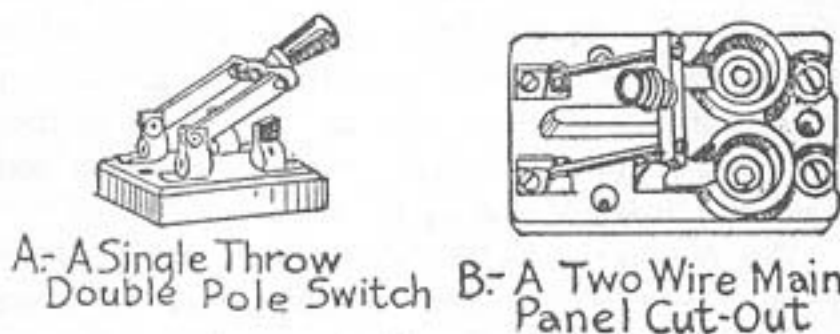


Fig. 132. Switches and Cut-outs.

is used only at the point where the inside wiring makes

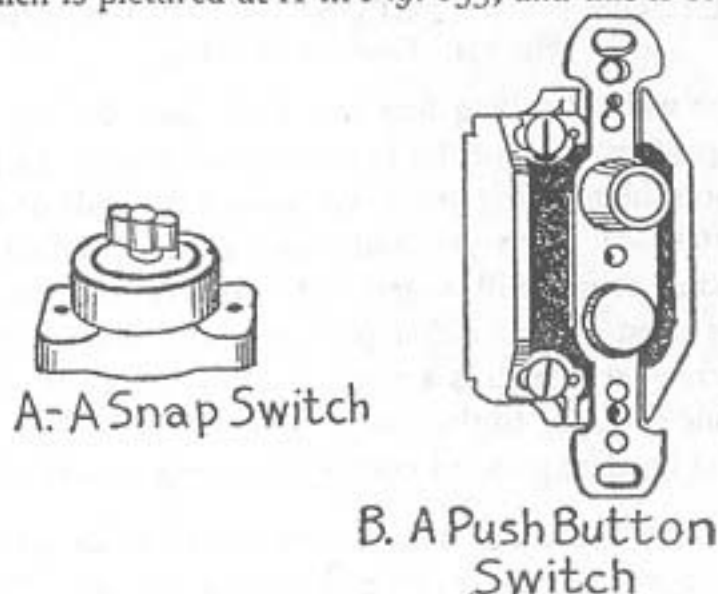
connection with the service wires of the generator or from the generator station that leads into the house. A switch of this kind is often placed in a small iron box called a *cut-out box*, and this should also contain a pair of *porcelain fuse blocks*, as shown at *B*. Wherever the lighting circuit makes connection with the service wires, there should be a pair of these *fuse blocks*. These blocks are made in different shapes, but those that have a screw socket like a lamp and whose fuse is contained in a metal shell that can be screwed into the socket are the kind that are generally used for lighting circuits.

Fuse plugs can be had with fuses of different current carrying capacities, but one that will carry five amperes at 125 volts is large enough for two or three lamps; where more lamps are used, fuses of larger carrying capacities must be used. The best way is to have two or more pairs of fuse blocks in different

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parts of the circuit, for then if one of them burns out the whole house will not be in the dark.

The second kind of a switch is the *snap switch*, which is pictured at *A* in *Fig. 133*, and this is screwed



B. A Push Button Switch

Fig. 133. Snap and Push Button Switches.

to the wall at any point where you want to turn the lights on and off. It is generally used where the wiring is exposed.

For Concealed Wiring.—When wires are run between the walls and ceilings and floors, the service wires from the generator or generating station must be led into the house through either porcelain bushings or iron piping, and these directly into an *entrance cut-out box*, that is, a sheet-iron box having a hinged door and in which is fixed the fuse blocks and the double-pole, single-throw switch.

The flexible armored conduit is led into the box and its wires are connected to the other side of the switch;

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the conduit is then led out to a point as nearly in the center of the branch circuits as possible. At this point the conduit is led into another iron box, called an outlet box, and the conduits for the branch circuits lead into it when all of the wires are connected up and soldered. The reason these boxes are used is so that the wires themselves shall at no time be exposed and hence cannot set fire to anything, should there be a short circuit between them.

Finally, where each of the conduits is brought out through a wall or a ceiling, so that the wires can be connected with an electrolier or a lamp bracket, it must be led into an *outlet box*; this is a small iron box that sets flush with the outside surface of the wall or ceiling, and which is concealed when the fixture that holds the lamp is screwed into it. An outlet box must also be used wherever the conduit leads to a switch.

The kind of a switch that is generally used for concealed wiring work is the *push-button switch* shown at *B* in *Fig. 133*. This switch on which the buttons and contacts are mounted is set in the wall and flush with it when the plate is screwed to it, thus making a very neat appearance.

The Tools You Need.—You need but very few tools to wire a house, and these are (1) a carpenter's hammer; (2) a carpenter's cross-cut saw; (3) an electrician's screw-driver; (4) a ratchet brace and three or four bits of different sizes; (5) a pair of six-inch lineman's pliers to cut off wires and to make splices and joints; (6) an electrician's knife to cut the insulation off the wires and to scrape them; (7) a gasoline blow torch, or an alcohol torch for solder-

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ing splices and joints, or heating a soldering copper; and (8) a soldering copper for soldering splices and joints.

Other Materials You Need.—To complete your equipment, you must also have (a) a box of soldering paste to smear on the splices and joints to make the solder stick well; (b) a roll of wire solder; (c) a roll of splicing compound, which is really a kind of rubber tape, and this is wrapped around the splice or joint after it is soldered; and (d) a roll of friction tape, which is used to wrap around the splicing compound to hold it in place.

How to Do the Work.—The first thing to do when you start to wire a house is to know to a certainty that the service wires that lead into the house are *dead*, that is, that there is no current in them. If

you have your own generating plant, this is easy, but if you have current supplied by the lines of a light, heat and power company, then you must get them to cut off the current.

For an *exposed wiring* job, begin by running a pair of approved rubber covered No. 12 or 14 wires from the double-pole, single-throw switch that is connected through the fuse block with the service line to some central point, in the basement if the house has one, and secure the wires as you go along to the beams with the porcelain cleats or knobs. Now cut the insulation off of the ends of the wires and scrape them bright.

Run as many pairs of wires from this as you want branch circuits to different parts of the house. Where the ends of wires are connected together, it is called

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a *splice*, and where the end of one wire is twisted around another wire that is continuous, it is called a *joint*. To make a splice, trim the insulation off of the ends of the wire and cross them, then twist the end of one of them around the other, and then twist the end of this one around the first one, which you can easily do with your pliers.

To make a joint, trim the insulation off of the lead wire about three inches long, and then scrape it; then trim the insulation off of the end of the branch wire and scrape it and twist it around the lead wire, which you can also easily do with your pliers.

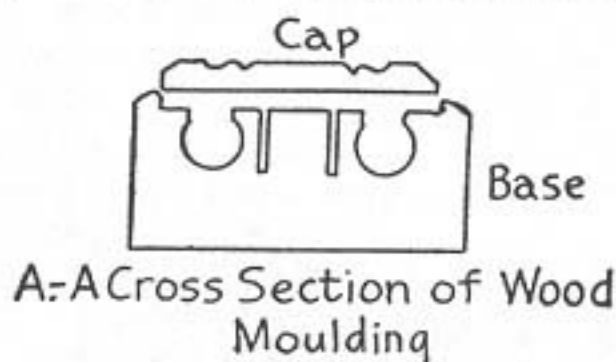
Whenever you make a joint or a splice, it must be soldered; a quick way to do this is to put a dab of soldering paste on the splice or joint, and then heat it with the flame of your blow-torch, being very careful not to burn the insulation, and touch it with the end of your wire solder. If you have to solder the splice or joint in a place where there is danger of burning the woodwork with the flame of the torch, then you will have to use the soldering copper.

After you have the splice or the joint soldered, cut off about six inches of splicing compound, which is the rubber tape, and wrap this spirally around the joint; when you have done this, cut off about the same length of friction tape and wrap this spirally around the splicing compound. When both of these tapes are on, the splice or joint is fairly well insulated.

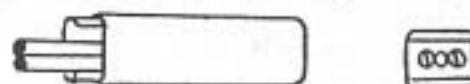
Where you want to cover up the wires you can buy *molding*, that is, wood or metal strips with parallel grooves in them, so that the wires can be laid side by side in them without touching. Either of these kinds

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are formed of a bottom strip, or *base*, as it is called, and a top strip, or *cap*, and these are shown in Fig. 134. When you use the molding, you screw the base



A-A Cross Section of Wood Moulding



B-Metal Moulding



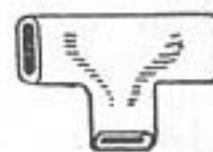
C-Base Coupling



D-Elbow



E-Cross



F-Flat Elbow

Fig. 134. Kinds of Moulding.

to the wall or ceiling first and then place the wires in the grooves and put the cover on with brads. In putting on the molding you must saw off the ends of it in a *miter box* when you come to a corner, so that the abutting strips will exactly fit. Where one pair of wires must cross another pair, you use what is called a *cross-over*, which is a piece of molding that fits over the one fastened to the wall or ceiling.

The hardest part, of course, in wiring an old build-

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ing where the wires must be concealed is to get the conduit between the walls and the ceilings and floors. To do this takes considerable ingenuity, much time, and a lot of patience. You must first *snake* a piece of telegraph wire between the walls or ceiling and floor, so that you can get hold of both ends through the outlets; this done, you can fasten the conduit to one end of the wire and pull it on through.

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XIV

ELECTRICAL UNITS AND MEASURES

ALL through this book the words *current*, *voltage* and *resistance* have been used, and it is high time that these factors, their relation one to another and how they are measured, should be explained in detail. To

know how an electric current acts when it is flowing through a wire, you need only to keep in mind that it has (1) *quantity*, which is termed *current strength*, and which is measured by a unit called the *ampere*; (2) *pressure*, which is the *force*¹ that drives the current along and which is measured by a unit called the *volt*;² and that the wire through which the current is driven has (3) *resistance*, which opposes the flow of the current, and which is measured by a unit called the *ohm*.³

¹ So called after Andre-Maria Ampere, founder of the Science of Electro Dynamics of France, born 1775, died 1836.

² Properly called the *electromotive force*.

³ Named in honor of Alessandro Volta, of Italy. Born 1745, died 1820.

⁴ Named in honor of George Simon Ohm, of Germany. Born 1781, died 1854.

Now, all of these factors bear a definite relation to each other, and if you know the value of any two of them, you can learn by a very simple arithmetical process what the value of the third and unknown factor is. Thus, (a) if you know the amperage and voltage of a current, you can find the resistance of the

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circuit through which it is flowing; or (b) if you know the voltage and the resistance, you can find the amperage, and, finally, (c) if you know the amperage and the resistance, you can find the voltage. Then again, the value of any one or all of these factors can be easily and accurately determined by means of measuring instruments, which will be explained presently.

The Electric Current and Its Circuit.—A good way to get a clear insight into how electricity acts when it is flowing through a wire is to think of it as so much water flowing through a pipe. In my recent book called "The Radio Amateur's Handbook" I explained by means of water analogues just how direct and alternating currents are set up in a circuit, and I cannot do better than to reproduce them here.

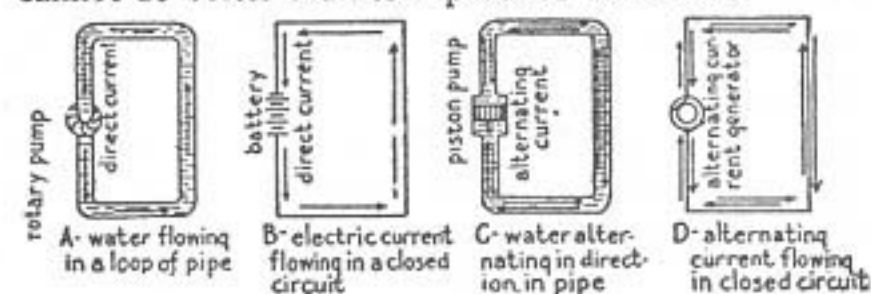


Fig. 135. Water Analogues for Direct and Alternating Currents.

rotary pump, as shown at A in Fig. 135; in the same way, to keep a quantity of electricity flowing in a loop

To keep a quantity of water flowing in a closed loop of pipe, which we will call the circuit, pressure must be applied to it and this may be done by means of a

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of wire, or circuit, either a battery, or some other means for generating electric pressure, must be used as shown at B, and this sets up a *direct current*.

But if you have a closed pipe connected with a piston pump, as shown at C, when the piston moves to and fro it forces the water in the pipe first one way and then the other, or in other words, the water will alternate in direction. Just so when an alternating current generator is connected to a wire circuit, as at D, the current will flow first in one direction and then in the other, and this sets up an *alternating current*.

Current and the Ampere.—The amount of water flowing in a closed loop of pipe is the same at all parts of it, and this is equally true of an electric current flowing in a closed circuit, in that there is exactly the same quantity, or *amperage*, of electricity at any one point of the circuit as there is at any other.

The amount of current, or amperage, flowing in a circuit in a second is measured by a unit called the *ampere*, and it is expressed in formulæ by the symbol *I*. The reason the letter *C* is not used as a symbol for current is because it was employed very early as a symbol for *capacity*, or *capacitance*, as it is now called. You can get a rough idea of the amount of current in an ampere from the fact that a fresh dry cell gives a current of about *twenty* amperes. To measure the current in amperes, an instrument is used called an *ammeter*, which you will find described farther on.

Electromotive Force and the Volt.—When you have a loop of pipe filled with water, or a circuit charged with electricity, neither will move unless pressure is applied to them. To set up pressure so that it

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will act on the water in a pipe and make it flow, you must use a pump, and to set up pressure so that it will act on the electricity in a circuit and make it flow, you must use a battery, or a generator of some kind, as you have previously seen.

The unit of electromotive force is the *volt*, and this is the electric pressure it takes to force a current of *one ampere* through a resistance of *one ohm*. The volt is expressed by the symbol *E*, since this letter is the first of those which form the word *electromotive force*. A fresh dry cell will set up an electromotive force (pressure) of about 1.5 volts, while a storage battery cell will set up an electromotive force of about two volts when it is fully charged. To measure the pressure of a current in volts an instrument called a *voltmeter* is used, which will likewise

be described later on.

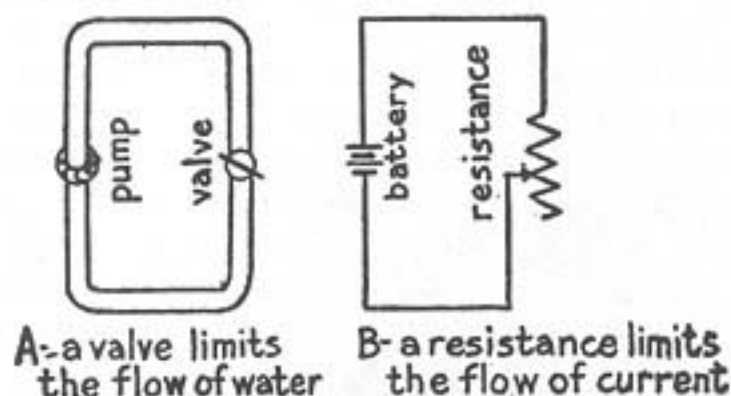


Fig. 136. Water Valve Analogue of Electric Resistance.

Resistance and the Ohm.—Just as water flowing through a pipe meets with a certain amount of *friction*, so in a like manner when an electric current flows through a wire it meets with a certain amount of resistance, and this is called the *resistance* of the circuit.

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Further, in the same way that the size of a pipe limits the amount of water that can flow through it, so, too, the size of a wire limits the amount of current that can flow through it.

You can also limit the flow of water in a pipe by means of a *valve*, as shown at *A* in Fig. 136, and in a somewhat analogous manner you can limit the flow of an electric current in a circuit by connecting in a *resistance coil*, or *rheostat*, as a variable resistance is usually called, as shown at *B*. The resistance of a circuit is measured by a unit called the *ohm*, and it is expressed by the symbol *R*. To measure the resistance of a circuit an apparatus called a *resistance box*, or *bridge*, is used. It is easy to figure out what the resistance of a circuit is, provided you have an ammeter and a voltmeter in the circuit through which the current is flowing.

What Ohm's Law Is.—As I have said in the beginning of this chapter, if you know (1) what the current flowing in the circuit is in *amperes*, and the electromotive force, or pressure, is in *volts*, you can then easily find what the resistance of the circuit is in *ohms* by this formula:

$$\frac{\text{Volts}}{\text{Amperes}} = \text{Ohms, or } \frac{E}{I} = R$$

Where *E* is the electromotive force in volts, *I* is the current in amperes and *R* is the resistance in ohms. Hence, from the above you will see that if you divide the electromotive force in *volts* by the current in

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amperes the quotient will give you the resistance in *ohms*.

Or, (2) if you know what the electromotive force of the current is in *volts* and the resistance of the circuit is in *ohms*, then you can find what the current flowing in the circuit is in *amperes*, thus:

$$\frac{\text{Volts}}{\text{Ohms}} = \text{Amperes, or } \frac{E}{R} = I$$

That is, if you will divide the electromotive force of the current in *volts* by the resistance of the circuit in *ohms*, you will get the *amperes* flowing in the circuit.

Finally, (3) if you know what the resistance of the circuit is in *ohms* and the current is in *amperes*, then you can find what the electromotive force is in *volts*, since:

$$\text{Ohms} \times \text{Amperes} = \text{Volts, or } R \times I = E.$$

That is, if you multiply the resistance of the circuit in *ohms* by the current in *amperes*, the result will give you the electromotive force in *volts*.

From the above formulæ you will see that if you know the value of any two of the factors you can find the value of the third and unknown factor by a simple process of arithmetic. This relation between these three factors is known as *Ohm's Law*, and as the formulæ are very important you should memorize them for future use.

What the Watt and Kilowatt Are.—Just as *horse-power* or *H. P.*, which is the symbol used for it,

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is the unit of work that steam has done or can do, so the *watt* is the unit of work that an electric current has done or can do. To find the *watts* a current develops, you need only to multiply the *amperes* by the *volts*, thus:

$$\text{Amperes} \times \text{Volts} = \text{Watts or } I \times E = W.$$

There are 746 *watts* in *one* horse-power and 1,000 *watts* are equal to *one* kilowatt.

How Electricity is Measured.—Since there is a definite relation between the *voltage* and the *amperage* of an electric current, and since magnetism, gravity, the energy of springs, and other forces follow definite laws, it is easy to contrive an instrument that will measure either the electromotive force, or the current strength, or both of these factors at the same time and

continuously.

How the Voltmeter is Made.—A voltmeter is always connected in *shunt* with the feed wires, that is, made somewhat on the principle of a galvanometer, across the circuit in which the current flows that you want to measure, as shown at *A*. The principle on which the voltmeter works is this: In the beginning of this chapter it was shown that according to *Ohm's law* the *electromotive force*, or *voltage*, is the product of the current multiplied by the resistance of the circuit it is flowing through, or, expressed as a formula, $C \times R = E$.

A diagram of a moving coil voltmeter is shown at *A* in *Fig. 137*, and a side view of the moving element it is shown at *B*, while a picture of the instrument complete is shown at *C*. By referring to *A* and *B*, you will see that the movable coil, which is formed of a cylinder of aluminum or copper, is mounted on a thin steel spindle with pointed ends. To each end of the spindle is fastened the inside end of a spiral spring, and the cylinder is then wound lengthwise with a large number

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of turns of fine wire. This completes the moving element and the spindle is mounted in jewelled bearings between the poles of a powerful permanent magnet.

The springs provide the force that opposes the counter magnetic forces of the permanent magnet and which are set up by the current flowing through the moving coil; the outside end of each spring is fixed to the frame of the voltmeter, and these are connected with the binding posts of the instrument, for it is by means of them that the current flows through the movable coil of wire.

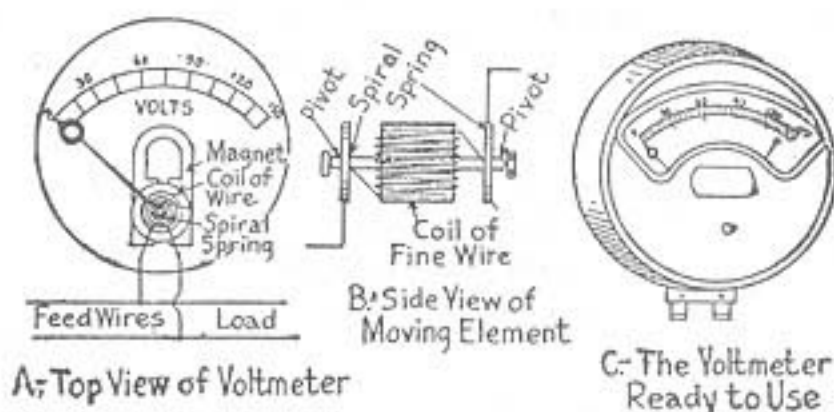


Fig. 137. How the Voltmeter is Made.

A needle, or pointer, is fixed to one end of the shaft, and this moves over a divided scale. Since the force of the spring as it is being wound up by the turning of the movable coil is proportional to the angle which it turns through, the deflection of the needle is proportional to the current, and this permits the scale to have the same length of space divisions from one end of it to the other.

How the Voltmeter Works.—The voltmeter is

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Now, when the current whose voltage is to be measured flows through the coil of fine wire, it sets up a magnetic field and this opposes the field of the permanent magnet. This action causes the coil to turn against the force of the springs, and since the resistance of the movable coil of wire is constant, the deflection of the needle will vary proportionately with the electromotive force, or voltage, of the current.

How the Ammeter is Made.—The ammeter, like the voltmeter just described, is a kind of galvanometer, but it is so wound and connected in the circuit whose current is to be measured, that the latter is indicated directly in amperes. The moving coil ammeter is made exactly like that of the moving coil voltmeter, except that the moving element is wound with much larger wire and all of the current—if this is not too large—is passed through it. The ammeter is connected in the circuit whose current strength is to be measured, in series as shown at *A* in *Fig. 138*, and the instrument complete is shown at *B*.

The Hot Wire Voltmeter and Ammeter.—This kind of a voltmeter and ammeter works on an entirely different principle from the closed coil voltmeter and

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ammeter, just described, and it can be used to measure oscillating currents, that is, currents of high-frequency such as are used in wireless telegraphy and telephony,

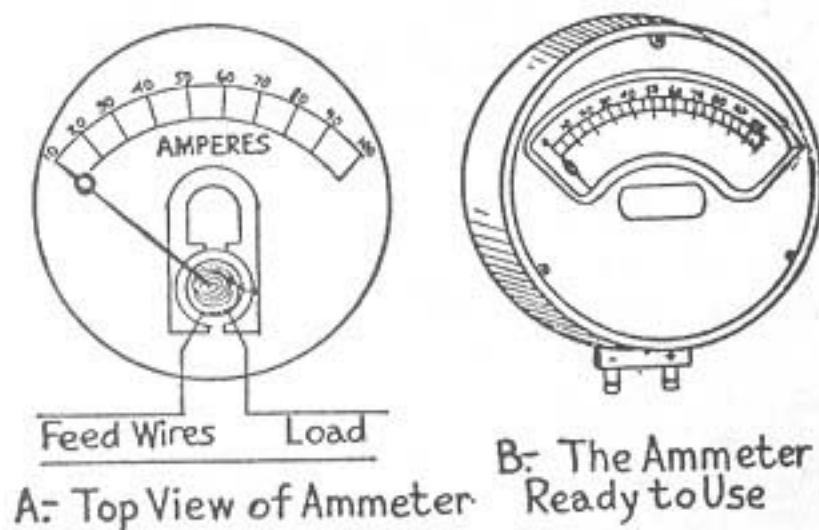


Fig. 138. How the Ammeter is Made.

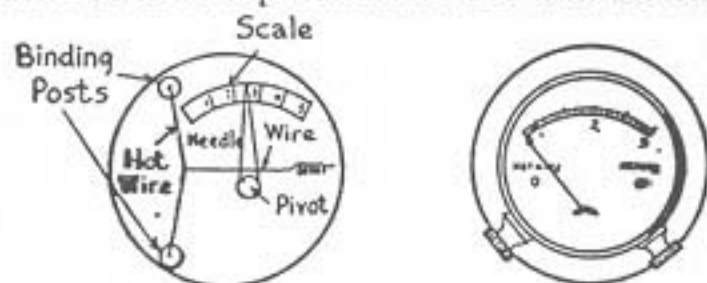
as well as for direct and alternating currents.

In these hot-wire instruments all, or part, of the current is made to pass through a fine wire and this heats it, when it expands accordingly. To the middle of the wire is fastened a fine wire, and the free end of this is fixed to a retractile spring. The middle of this wire is fastened to a needle, or pointer, whose free end moves over a graduated scale. The way these instruments are made is shown at *A* in *Fig. 139*, and the instrument itself at *B*.

How to Measure Watts and Watt-Hours.—The kind of a meter that the electric light companies install in houses for the measurement of the amount of electricity that is used is called a *watt-hour meter*, and it is a kind of combination voltmeter and ammeter with a series of dials on it like a gas-meter.

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Now you will remember that (1) amperes multiplied by the volts gives you the total energy in watts, that is, $\text{amperes} \times \text{volts} = \text{watts}$; (2) that there are 746 watts in one horse-power, and (3) that there are 1,000 watts in one kilowatt. Now, while the ampere is the unit of current strength (or quantity) and the volt is the unit of electromotive force (or pressure) so the watt is the unit of electric power and the watt-hour is the unit of electric work. The watt-hour means then, that there is an expenditure of one watt for one hour.



A- Diagram of a Hot Wire Ammeter

B- The Hot Wire Ammeter Ready to Use

Fig. 139. The Hot Wire Ammeter for Wireless Work.

Difference Between a Watt Meter and a Watt-Hour Meter.—A *watt meter* is a kind of galvanometer that makes it possible to measure the voltage and the amperage of the current that is passing through it at any given instant in exactly the same way that an ammeter measures the current strength and a voltmeter measures the electromotive force that is passing through them at any given instant.

A watt meter consists of two coils of wire, one of which is made of coarse wire and the other one of fine wire, and these are set at right angles to each other. The coarse wire coil is fixed to an upright support, and

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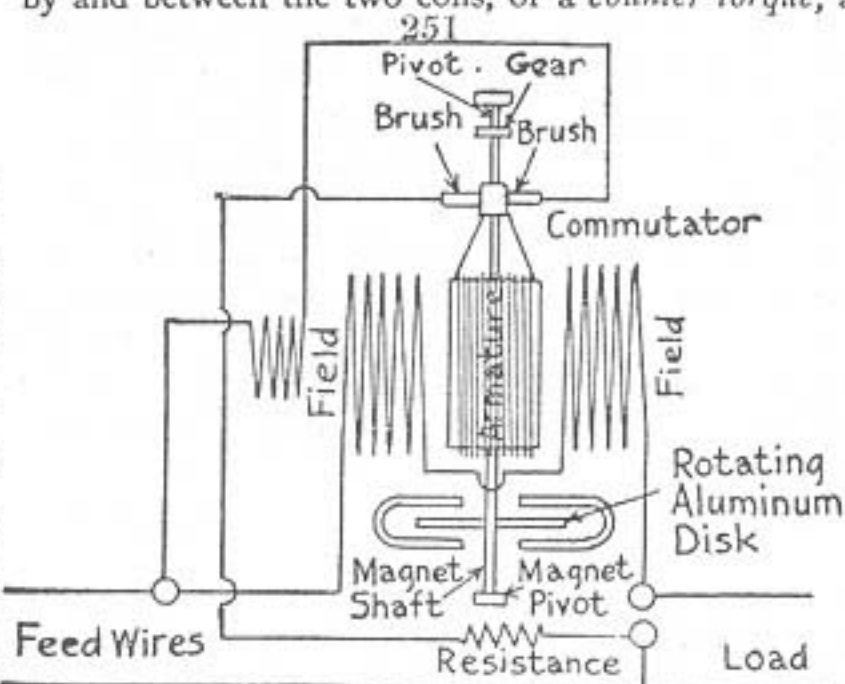
the coil of fine wire is pivoted so that it can turn easily

inside of the fixed coil. Both coils are connected together so that the current to be measured flows through them at the same time. As in the voltmeter and ammeter previously described, the movable coil is controlled by a spring and a needle, and a needle is fastened to the spindle of the movable coil. It is clear, now, that the spring prevents the movable coil from turning completely around.

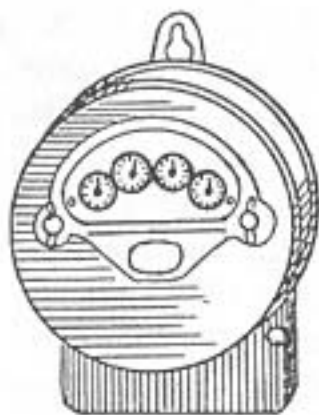
To measure the watts, the movable coil is set at right angles to that of the fixed coil, and the current which is to be measured is made to flow through the coils. The current sets up a magnetic field in both coils, and as these react on each other they tend to set in a line with each other. This action gives a reading in terms of watts at any given instant.

What the Watt-Hour Meter Is.—A watt-hour meter differs from a *watt meter* in that it measures the amount of the electric energy of the current in *watts* during the *time* it is being used. The diagram *A* in *Fig. 140* shows how a watt-hour meter is made, and you will see that it is very like the watt meter just described in that it has a fixed coil of coarse wire and a movable coil of fine wire, but instead of the latter turning against a spring which limits its distance of rotation, the former has no springs and so is free to rotate continuously.

To allow it to do this, a commutator is placed on one end of the shaft and the current is led into the movable coil and taken off by a pair of brushes as it is in a generator or a motor. To the end that there may be an opposing force on the movable coil against the action of the mutual magnetic fields, which are set up by and between the two coils, or a *counter torque*, as



A- Wiring Diagram of a Watt Hour Meter



B.-The Watt Hour Meter Ready to Use

Fig. 140. How the Watt Hour Meter is Made.

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it is called, an aluminum disk is mounted on the spindle and this rotates between the poles of two permanent magnets.

The purpose of the counter torque is, therefore, the same as that of the springs in the meters previously described, namely, so that the opposing force on the movable coil will be proportional to the electric power, or watts, of the current which is being measured. To show the amount of electric power, or watts, that is being used, or has been used per hour, a small worm, or gear, is fixed to the spindle of the movable coil and this drives a train of gears.

These gears are so proportioned that when the first dial has made *ten* revolutions the second one has only made *one* revolution, and so on. The dials are divided off to represent either *watt hours*, where small amounts of electric power are used, or *kilowatt hours*, where large amounts of power are used.

How Resistance is Measured.—To measure the resistance of a length of wire or other conductor in *units of ohms*, a *Wheatstone bridge* is generally used. This consists of a *resistance box*, connected with a galvanometer and a battery. The resistance box is arranged so that resistance coils of different values can be switched, or plugged, in the circuit and balanced against the resistance of the wire which you want to know. A resistance box is quite expensive, but where resistances are to be constantly, quickly and accurately measured, it is a necessity.

Measuring with a Voltmeter and an Ammeter.—

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An easy way to find out what the approximate resistance of a length of wire is in *ohms*, is to find the amperes and the volts of a current flowing through it, and then make a simple arithmetical calculation. To

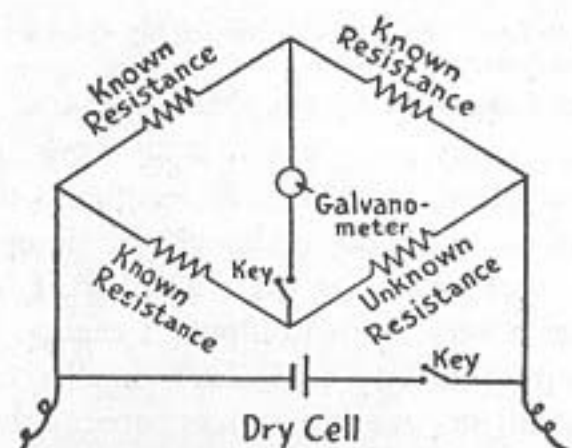


Fig. 141. How the Resistance Bridge is Made and Used.

do this, you need only to connect a voltmeter, an ammeter, a battery and a switch in circuit, with the wire whose resistance you want to know, as shown in Fig. 142.

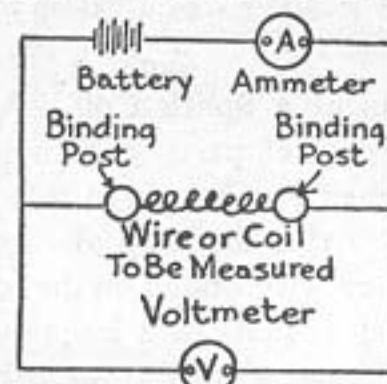


Fig. 142. How to Find the Resistance With a Voltmeter and an Ammeter.

This done, close the switch and then read off the volts and amperes from the meters; knowing these,

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you have only to divide the voltage by the amperes and the result will give you the resistance of the wire in *ohms*. This scheme of finding the resistance of a wire or other circuit is known as the *fall of potential* method, and the reason for it is due to the fact that the drop of voltage of a current is directly proportional to the resistance of the wire, or other conductor, it is flowing through.

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XV

THE SPARK COIL AND HOW TO MAKE IT

THE spark coil, induction coil, and Ruhmkorff coil, are one and the same piece of apparatus. It was first called a *Ruhmkorff* coil because a famous instrument-maker of Paris named Ruhmkorff was the first to make a coil that would give a long spark. Many years later, and after it had been greatly improved by other workers, it was generally called an *induction coil*, because high tension currents are set up in it by *induction*, but since the advent of wireless and motor cars' it has been called, simply, a *spark coil*.

¹ Spark coils are often used for setting up sparks to fire the fuel charges of gasoline engines.

About the Sizes of Spark Coils.—Spark coils for wireless telegraphy and experimental work that give sparks from one-quarter inch in length up to six or eight inches in length can be bought in the open market. As a spark coil that gives a spark of less than one inch has a very limited output of energy, it is not advisable either to buy or build a smaller one than this, and when you want to use more energy than these larger sizes will give, it is better to use a *step-up transformer*.² A small spark coil can be worked with a battery current, while the larger sizes should be energized with a 110-volt lighting current.

² You can buy a spark coil or a step-up transformer of dealers in wireless apparatus in general.

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The Parts of a Spark Coil.—A spark coil consists of seven chief parts, and these are (1) a *core* which is formed of a bundle of soft iron wires; (2) a *primary coil* that is made up of a couple of layers of heavy insulated wire wound on the core; (3) a *secondary coil* which consists of a large number of turns of very fine insulated wire; (4) an *interruptor*, or *vibrator*, as it is generally called, that makes and breaks the current as it flows through the primary coil; (5) a *condenser*, which is built up of a large number of sheets of tin-foil and paper; (6) a *spark gap* formed of a pair of pointed brass rods, or rods with balls on them; and (7) a *base* on and in which all of the above parts are mounted.

How to Make a One Inch Spark Coil.—By a *one inch* spark coil is meant a coil that will give a spark one inch in length. It is best to get together all of the materials you need before you start to work. The materials will include: (1) one pound of No. 18 or 20 soft, black iron wire for the core; (2) fifty feet of No. 14 double-cotton-covered magnet wire for the primary coil; (3) one and one-half pounds of No. 36, 38 or 40 single-cotton-covered magnet wire for the secondary coil; (4) two large binding posts for the primary terminals; (5) two small binding posts for the secondary terminals; (6) a four inch length of one-half inch brass rod for the vibrator standards; (7) a piece of spring brass, or phosphor-bronze, which is better, or steel clock spring, one-half inch wide and two and one-half inches long, for the vibrator spring; (8) a soft iron disk one-half inch thick and three-quarters of an inch in diameter for the armature; (9)

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a three-thirty-seconds of an inch thick piece of plati-

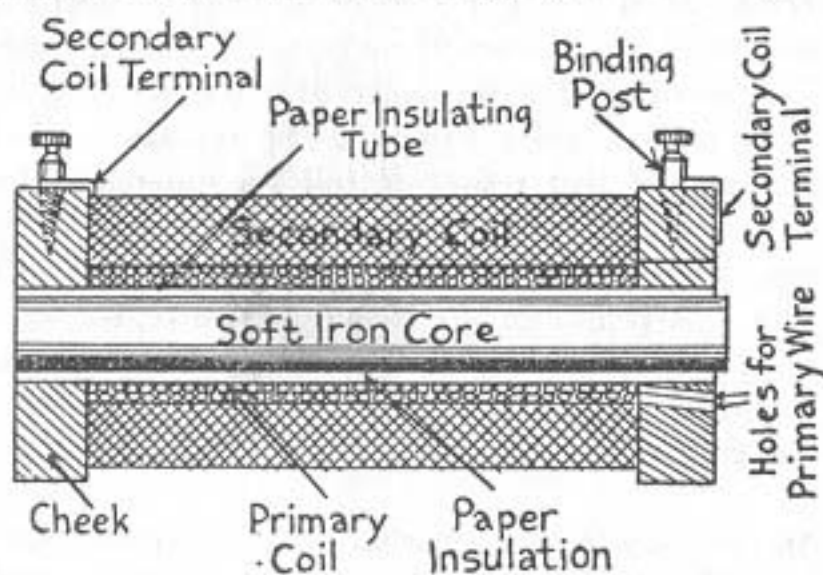
num wire one-quarter inch long for the contact point; (10) a platinum wire three-thirty-seconds of an inch thick and one-eighth of an inch long for the fixed contact disk; (11) one pound of tin-foil for the condenser; (12) seventy-five sheets of 8 x 10 good thin bond writing paper, also for the condenser; (13) a pair of brass wires one-eighth inch in diameter and five and one-quarter inches long for the spark-gap rods; and (14) some hard wood one-quarter inch thick for the base.

If you intend to make the vibrator,¹ you must have (1) a hack saw, to saw off the brass rods and cut the slot in the adjusting screw standard; (2) three drills one-sixteenth inch, three-thirty-seconds of an inch, and one-eighth inch in diameter; (3) a drill stock; (4) one 6-32 and one 8-32 tap for cutting inside screw threads; (5) a pair of dies for cutting outside threads that will fit the above taps; (6) a stock for the above taps and dies; (7) a couple of files; (8) a screw-driver; (9) a small hammer; (10) a machinist's vise; and (11) a soldering outfit. With the above materials and tools at hand you are ready to begin the work of constructing the coil.

How to Make the Spool.—The spool consists of an insulating tube, as shown at *A* in *Fig. 143*, in which the core is placed, and a cheek (See *B*) fixed to either end of it, to hold the primary and secondary coils in place, as at *C*. To make the spool, get either a hard fiber tube, or else make one of paper, one inch in

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diameter, outside measurement, and seven and one-half inches long (See *A* again). To make a paper tube, take a long strip of thick manila paper seven and one-half inches wide and wrap it tightly around a cylin-



D-Longitudinal Cross Section of the Coil

(D) Fig. 143. How a Spark Coil is Made.

drical stick seven-eighths of an inch in diameter until the wall of the tube is one-sixteenth inch thick, and paste, or glue, it together as you go along.

Next saw out, or have sawed out, two disks of wood three-quarters of an inch thick and three and one-quarter inches in diameter, for the cheeks of the spool, or you can use two boards that are three and one-quarter inches on the sides. Saw, cut or bore out a hole one inch in diameter in the center of each cheek, as at *B*, and drill two one-eighth inch holes about one inch apart through one of the cheeks for the ends of the primary wire to come through. Now smear some

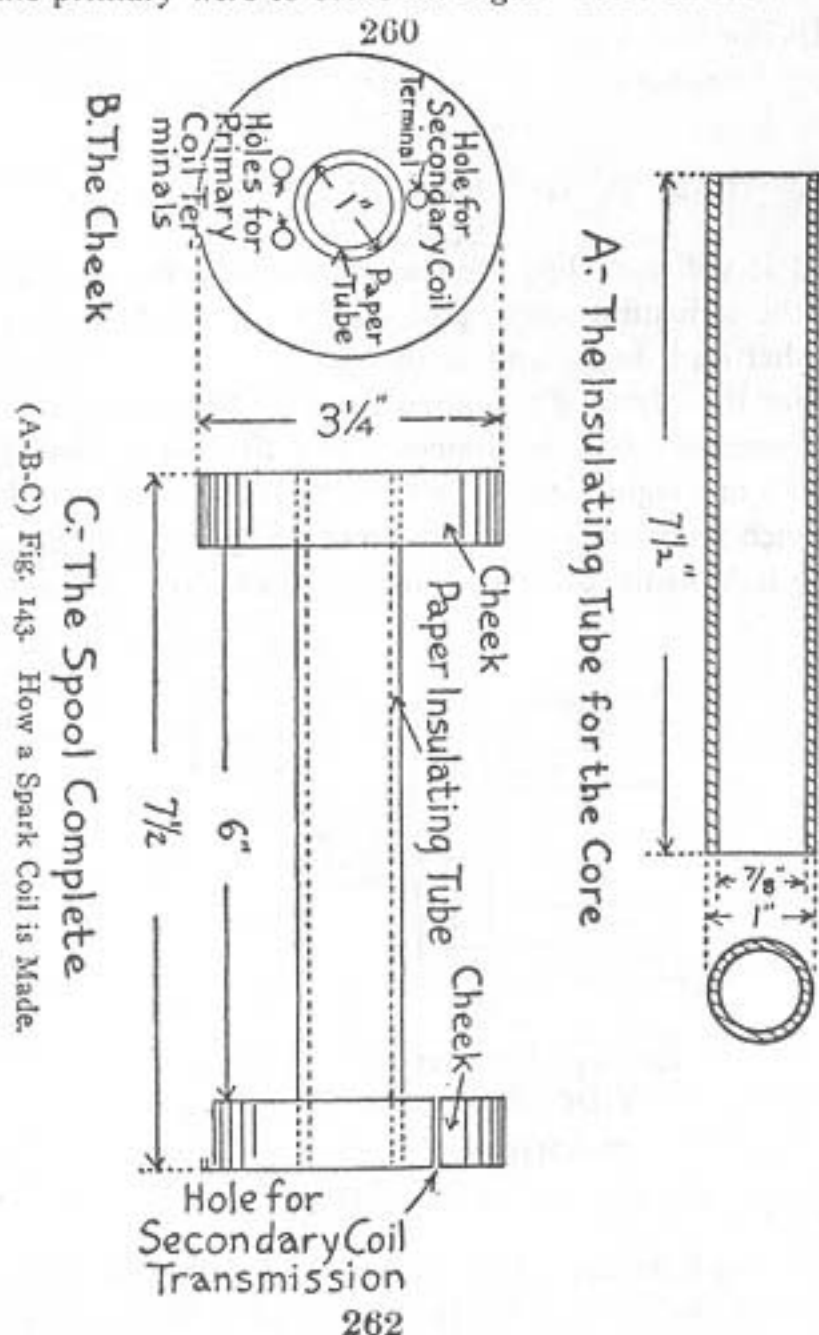
diameter, put them in the tube and keep on worrying one or two in at a time until you have it as full as you can possibly get it. One end of the core should be flush with one end of the tube, while the other end of the core should project beyond the other end of the tube one-eighth inch, as shown in the cross-section of the coil at *D*.

How to Wind the Primary Coil.—You are ready now to wind on the wire for the primary coil. To do this, begin by slipping one end of the heavy double-cotton-covered magnet wire through the hole that is nearest the core (See *B* and *D*) and wind it on very carefully so that each turn is smooth and lies up close to the turn next to it. After you have the first layer put on, give it a good coat of shellac varnish and then wind on the second layer; when you have this on, cut the wire off so that there will be about a foot left, and slip this end through the second hole in the cheek, which is also shown at *B* and *D*. Now give this layer a good coat of shellac and then wrap a couple of thicknesses of manila paper over it; shellac this well also, and when this is dry you are ready to wind on the secondary coil.

How to Wind the Secondary Coil.—To wind the fine wire around the primary coil and make a good job of it is not at all an easy matter, and to do it the easiest way is to wind it on a lathe. In every town, fortunately, where there is a locksmith, a gunsmith or a machinist, you will find a lathe, and it is never very hard to get the use of it to wind up the secondary and, usually, you will have all the help you want to do it with besides.

If there is no lathe available, then you will have to make a *winding machine*. This you can do by screwing two wood supports about two inches wide and six inches long to a base of wood eight inches wide and ten inches long. Through the top of one of them put a wood screw, which will serve as a pivot for the spool to revolve on; through the top of the other support mount a crank, the spindle of which has a screw-driver edge, so that it can set into the end of the core to turn it. A winding machine of this kind often comes in handy for other electrical work, and if you have an experimental laboratory or shop it is a piece of apparatus that will often prove useful.

When you start to wind the secondary coil, slip the end of the wire through the hole in the cheek of the coil that is nearest the primary coil, as shown at *B*, *C* and *D*, and bring it to the outside. Now wind on a



(A-B-C) Fig. 143. How a Spark Coil is Made.

glue on the ends of the fiber, or paper, tube and set a cheek on each one, as at *C*. This will give you a spool three and one-quarter inches in diameter and six inches long, inside measurement.

How to Make the Core.—Cut the soft iron wire up into seven and five-eighths inch lengths and straighten them out very carefully; when you have enough to make a bundle seven-eighths of an inch in

layer of the wire and give it a coat of shellac, then wind on the next layer, shellac it, and so on, until the spool is full of wire. A better insulation can be had by running the wire through a melted compound made of resin and beeswax.

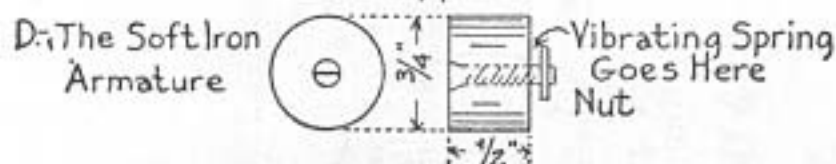
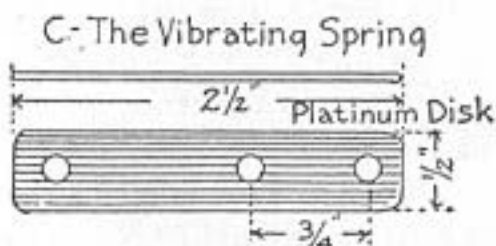
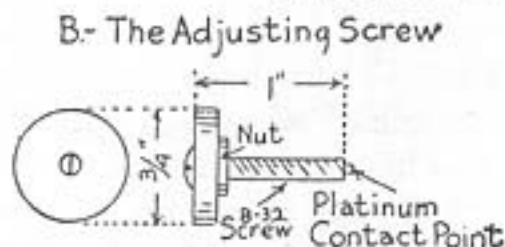
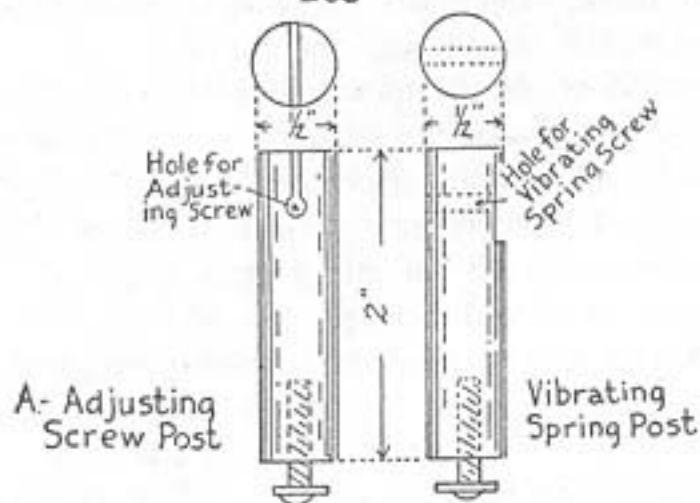
After you have the secondary coil wound, screw a binding post in the top of each cheek, as shown at *D*,
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and connect the end of the inside wire with one of them and the outside end with the other one. Finally, cover the outside of the coil either with paper, or better, because it makes a neater looking job of it, with a piece of bookbinder's cloth, or still better, you can cover it with a very thin sheet of hard rubber; this you can do by drilling a row of holes in the ends of the sheet, then bending it around the coil and lacing it together with a piece of fish-line; this will give your coil a very professional look.

How to Make the Vibrator.—The interruptor, or *vibrator*, as it is popularly called, consists of the following parts, namely (a) an adjusting screw post; (b) an adjusting screw; (c) a vibrating spring post; and (d) a soft iron armature, all of which are shown in detail in *Fig. 144*.

For the adjusting screw post get a piece of brass rod one-half inch in diameter and two inches long; drill a three-thirty-seconds of an inch hole through it three-eighths of an inch from one end and drill a three-thirty-seconds of an inch hole one-half inch deep in the other end; tap out both of these holes with an 8-32 tap and saw a slot through the rod until it meets the hole. For the adjusting screw get an 8-32 brass screw, one inch long, and drill out the end of it with a fine drill, and drive a bit of platinum wire three-thirty-seconds inch in diameter and one-quarter inch long, as shown at *B*; now slip a hard rubber, or a composition, disk about three-quarters of an inch in diameter over the screw, and screw up a nut on it so

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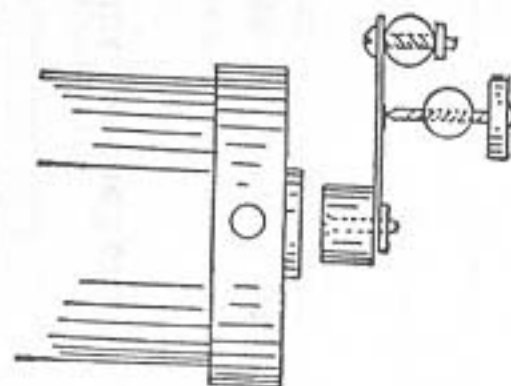


(A-D) *Fig. 144. How the Vibrator is Made.*

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that it will not slip; then screw the adjusting screw in the adjusting screw post and put a screw with a washer on it in the end of the post.

For the vibrating spring post, cut off a piece of brass rod one-half inch in diameter and two inches long; drill a one-eighth inch hole through it three-eighths of an inch from one end, and a three-thirty-seconds of an inch hole in the other end one-half inch deep; tap out



E: Top View of the Vibrator and Mounting

(E) *Fig. 144. How the Vibrator is Made.*

the latter hole through it three-eighths of an inch from one end, and a three-thirty-seconds of an inch hole in the other end one-half inch deep; tap out the latter hole with an 8-32 tap and put a screw with a washer on it into it. Finally, smooth up both posts with a file.

Now get a piece of heavy spring brass, phosphor-bronze, or steel, one-half inch wide and two and one-half inches long, and drill, or punch a one-eighth inch hole in each end of it, and three-quarters of an inch

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from the end holes punch a one-thirty-second inch hole. Push a three-thirty-seconds inch long piece of platinum wire in the middle hole and peen it down with a hammer until it has spread out into a flat disk on one side about one-eighth inch in diameter, as shown at *C*. This done, slip a screw with a washer on it through the hole nearest the platinum disk; then put it through the hole in the vibrating spring post and finally screw on a nut.

Last of all, get a soft iron rod three-quarters of an inch in diameter and saw off a piece one-half inch long; file it up smooth and drill a three-thirty-seconds inch hole through the center of it, and counter-sink one of the ends of it; slip a 6-32 flat headed machine screw through it and on through the hole in the free end of the vibrating spring, and put a nut on it. This completes the parts of the vibrator and it is now ready to be assembled on the base of the coil, as shown at *E*.

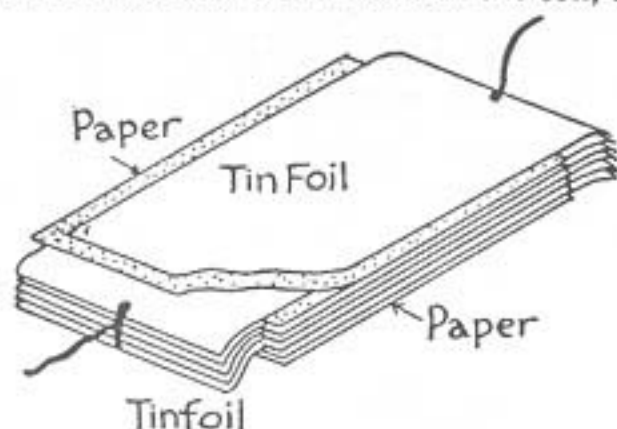


Fig. 145. How the Condenser is Built Up.

How to Make the Condenser.—As I have mentioned before, the condenser is built up of alternate

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leaves of paper and tin-foil, every other leaf of the latter projecting beyond the paper a little on the right and the left hand side, as shown in *Fig. 145*. To make the condenser, cut out about two hundred sheets of good thin writing paper, which must be absolutely free from pin holes or other punctures, four and one-half by eight inches on the sides; and then cut out an equal number of sheets of tin-foil four by eight inches on the sides.

To build up the condenser, drive four large pins into a smooth board to serve as a form. Lay a sheet of paper against the pins, then a sheet of tin-foil on the paper so that the latter will have an even margin all around it, except on the right hand end, which must lap over; next lay on another sheet of paper, and over this another sheet of tin-foil; this time bring one of the ends of the latter over to the left hand side and so

on, until all of the leaves of paper and tin-foil have been laid up; then put a sheet of pasteboard on the top and the bottom of the condenser, and tie it together with a piece of string.

Next cut off a couple of pieces of copper wire ' about six inches long and solder one end of each one to the opposite ends of the tin-foil. To do this, use a soldering copper that has been freshly tinned, some good soft solder and resin for the flux, and you must be very careful that you do not melt the ends of the tin-foil. This finishes up the condenser, and the next thing to do is to make the base for your induction coil.

'Flexible stranded wire is the best.

How to Make the Wood Base.—Make as neat a box base as you can of any kind of hard wood that

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you can get. By a box base is meant a base that is made like a box, that is, it has a top, bottom, ends and sides, and is hollow. Use one-quarter inch thick stuff and have it five inches wide and ten inches long, outside measurement. Make the ends and sides two inches high, and glue these to the top, as shown at *A* in *Fig. 146*. Cut a bottom out of any kind of thin wood

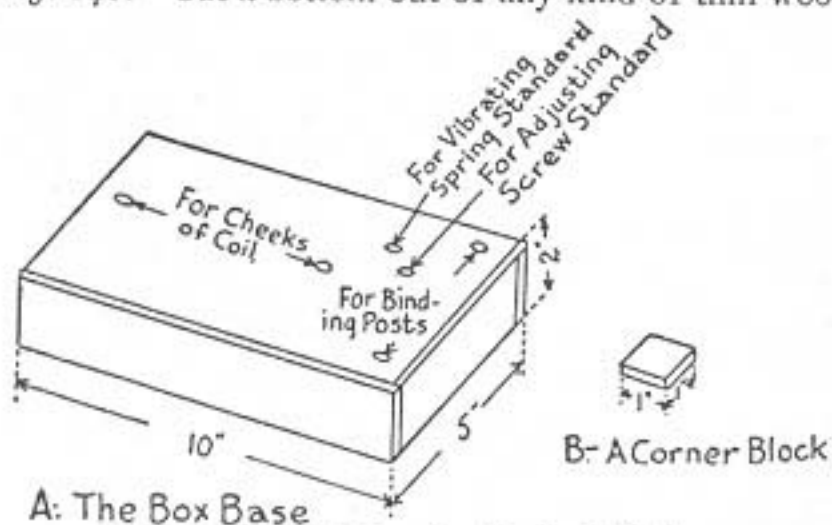


Fig. 146. The Base for the Spark Coil.

and have it of such size that it will just slip into the base. This done, make four base blocks of one-quarter inch thick stuff one and one-half inches square, as shown at *B*.

How to Assemble the Parts.—The first thing to do is to mount the vibrator on top of the base together with the binding posts, and to do this drill four one-eighth inch holes through the top at the points, as shown; and you can drill two more of them at the same time for the screws that are to hold the coil to the base, and also two more for the ends of the primary coil to pass through.

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Screw the vibrating spring standard to the base

first, then the adjusting screw standard, and the binding posts next. Loop a piece of wire around each of the screws between its head and the washer inside of the base, and then screw each one up tight. Finally, fix the coil to the top of the base with a couple of wood screws, and then set the condenser inside of it, when you are ready to wire up the coil.

How to Wire Up the Coil.—The diagram given in Fig. 147 shows how the spark coil is wired up.

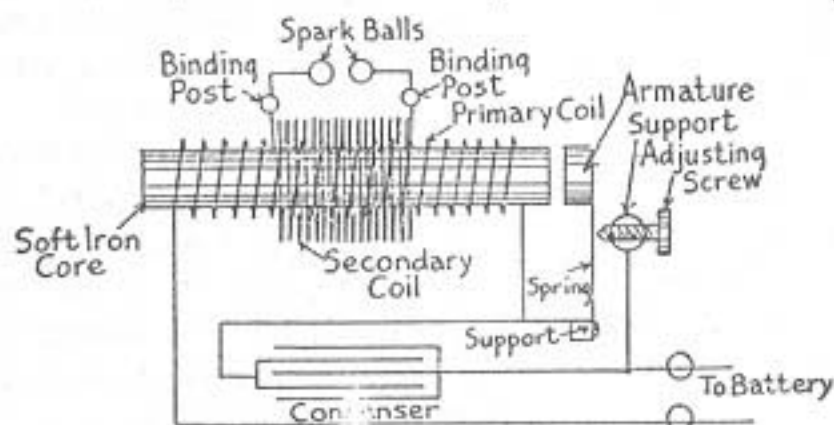


Fig. 147. Wiring Diagram for the Spark Coil.

First connect one of the binding posts on the base to the screw of the adjusting screw post, and also connect it with one of the end wires of the condenser. Next, connect the other binding post with one of the ends of the primary coil, and the other end of this with the screw of the vibrating spring support and also with the other end wire of the condenser.

In wiring up the spark coil, be very sure that the wires are clean and bright and that the connections are perfectly tight. Secure the condenser in the bottom of the base. Now put the bottom in the base of

the coil and to hold it in place glue or screw the base blocks on to the corners. Finally, slip the spark-gap rods through the binding posts on top of the cheeks, when your spark coil will look like Fig. 148 and is ready for work.

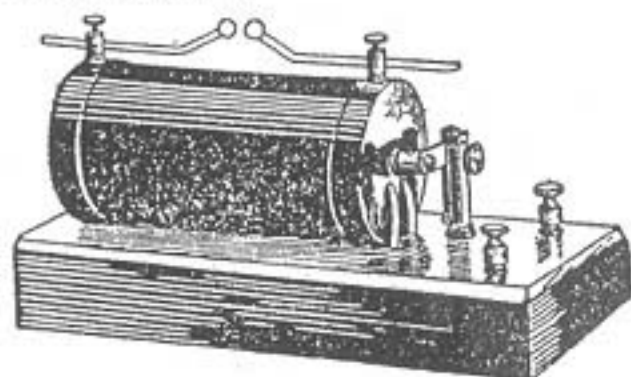


Fig. 148. The Spark Coil Complete.

How to Work the Spark Coil.—Push the spark-gap rods together until the points, or balls, are about one-quarter inch apart. Unscrew the adjusting screw

until the point on the screw and the disk on the spring are separated a little. Now connect the primary binding posts with a battery that will develop at least six volts; but all primary cells will run down very quickly if the coil is kept in operation for any length of time.

If you use a storage battery to energize the coil, it is a good scheme to connect a *rheostat*, that is, a variable resistance, in the primary circuit. Under no circumstances, connect the coil with a 110-volt circuit, unless you have a fuse block, double-pole, single-throw switch in the primary circuit, and then you must be very careful when you cut out the resistance.

When you have the coil connected with a source of current, screw up the adjusting screw very slowly until the point of it just makes contact with the disk on the spring. The spring should then begin to vibrate without having to be started. When it does so you can screw up the adjusting screw a little more and pull the spark-gap rods farther apart, but never pull them more than one inch apart, or the secondary coil may break down. As you screw up the adjusting screw, the point and disk make better contact and more current will flow through the primary coil, and the spark will get whiter and fatter.

Theory of the Spark Coil.—You have already seen in Chapter V that when a current flows through a wire it sets up a magnetic field around it, and that when an insulated wire is wound into a coil and the ends of the latter are connected with a battery, it develops a powerful magnetic field.

Now when two coils of wire are placed close together the electro-magnetic induction between them is *reactive*, that is, when a current is made to flow through one of the coils closed magnetic lines of force are set up around and at right angles to it, and when these cut the turns of wire of the other coil they in turn set up electric currents in it, and this is called *mutual induction*.

It is the mutual induction that takes place between two coils of wire which makes it possible to transform the *low voltage current* from a battery, or a 110-volt lighting current, into high pressure currents or *high potential currents* as they are called, by means of a spark coil, or a transformer.

How the Spark Coil Works.—When the adjusting screw makes contact with the spring of the vi-

brator, the primary circuit which includes the primary coil of the spark coil and the battery, or other source

of current is closed, and the current then flows through the primary coil. As it does so two things take place, and these are (1) the core is magnetized and (2) the magnetic lines of force that are set up around it *expand*, and as they do so they cut the wires of the secondary coil, when a current is set up in them in one direction.

The instant the core is magnetized it pulls the armature, which is fixed to the spring, toward it, when the contacts of the adjusting screw and the spring are separated, and this breaks the current that is flowing in the primary coil. Again, two things take place, namely (1) the core is demagnetized and (2) the magnetic lines of force that are set up around it *contract*, and as they do so they cut the wires of the secondary coil again, when a current is set up in them in the other direction.

In this way, then, every time the contact points of the vibrator make and break the circuit, an alternating current is set up in the secondary coil, and as the vibrator interrupts the current several hundred times every minute there are an equal number of alternating currents set up in it. Farther, and equally important, the secondary coil steps up the *pressure*, or *voltage*, of the coil enormously as against that of the current which flows through the primary coil.

This it does in virtue of the fact that there is a small number of turns of wire on the primary coil and a very large number of turns of wire on the secondary coil. As an illustration, if the primary coil is formed

of ten turns of wire, and the secondary coil is formed of one thousand turns of wire, then the pressure, or voltage, of the currents that are set up in the secondary coil will be one hundred times as high as that of the current flowing in the primary coil. The *amount of current*, or *amperage*, will be proportionately smaller so that we have a high potential current of very small amperage at the terminals of the spark gap.

Finally, the condenser shunted across the contact points of the vibrator is necessary to prevent the current from jumping across them, or *arcing*, as it is called, when the break takes place. This it does by taking up the current, that is, the latter *charges* it instead, and when the circuit is again made the condenser discharges through it and this gives the primary coil an extra *kick*, which further increases the potential, or voltage, set up in and by the secondary coil.

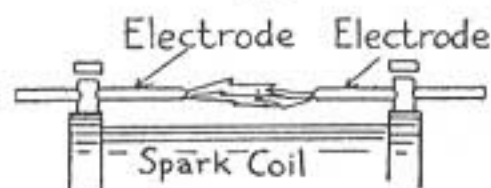
SOME EXPERIMENTS WITH YOUR SPARK COIL

THERE are a large number of startling and very spectacular experiments that you can make with a spark coil, and it has, besides, numerous practical uses, such as producing sparks for igniting the fuel charges of gas and gasoline engines, energizing X-ray tubes, setting up electric oscillations for wireless telegraphy, etc. In this chapter I shall tell you how to make some entertaining and instructive experiments with your spark coil. Others you can devise for yourself.

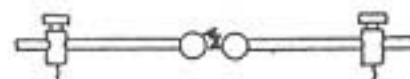
The Electric Spark Between Points.—Connect your spark coil up with a key and battery, as described in the preceding chapter, and slip a pair of bent pointed wires into the binding posts on top of the spark coil, which, you will remember, are connected with the ends of the secondary coil, as shown at A in Fig. 149.

Now, (1) separate the points about one inch and press down on the key, when a reddish, stringy spark will jump across the gap. Next, (2) set the points about one-eighth inch apart, when the spark will be whiter and fatter. This is because the longer the spark gap is, the higher the voltage must be to break down the air in the gap, and the smaller the current will be.

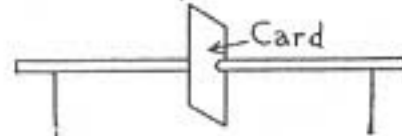
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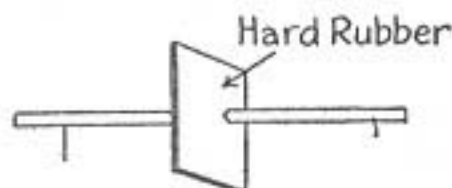
A: The Spark Between Points



B: The Spark Between Balls



C: Making the Spark Punch a Hole



D: Making the Spark Longer

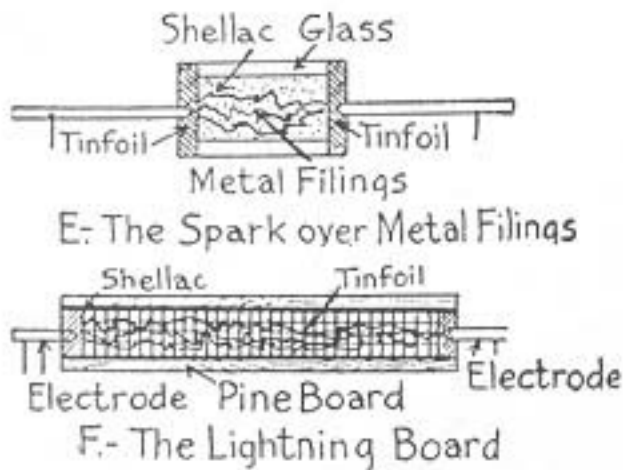


Fig. 149. Some Experiments With the Electric Spark.

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The Electric Spark Between Balls.—Slip a pair of little balls on the ends of the bent wires, as shown at *B*, and you will find that the spark will not jump as far between them as when you used the points, but the spark will be fatter and whiter for the same spark-lengths, which shows that more current (*amperage*) is passing between them. The reason the spark is shorter is because the balls must be charged with electricity before the spark can pass, and this takes current (*amperage*); when the pressure (*voltage*) is high enough, the charge on the balls then discharges across the gap.

Making the Spark Punch a Hole.—Take the balls off of the spark-gap points and separate the latter about one-sixteenth inch; now hold a visiting card, or a business card, between the points, as shown at *C*, and close the primary circuit by pressing down on the key. On removing the card you will see that the spark has made a needle-like hole through it, and you will also observe that there is a burr around the hole on both sides of the card. This shows that the current which produces the spark is *oscillatory*, that is, it surges first in one direction and then back again between the points.

How to Make the Spark Longer.—By holding a thin sheet of hard rubber between the *electrodes*, as the spark-gap points are called (See *D*), the spark will jump up and over the edge of it, and, further, the length of it will be greatly increased, as well as the crackle of the spark. The reason the sheet of hard rubber increases the length of the spark is because there is just enough moisture on it to act as a con-

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ducting path. Another reason is that the hard rubber is so much better dielectric than the air that the gap resistance is that of the hard rubber.

Making a Spark Take the Longest Path.—

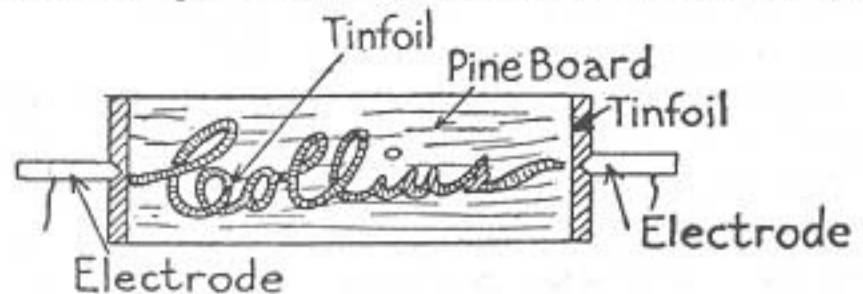
Slightly dampen the ends and the side of a sheet of hard rubber and hold it so that the ends touch the spark-gap electrodes. The spark will follow the moist path rather than jump across the shorter distance between the two pointed electrodes. As before, this is because the moisture on the hard rubber is a conductor and the air between the points is an insulator of the oscillating electric currents.

The Spark Over Metal Filings.—Take a sheet of glass about four by five inches on the sides and spread a layer of thick shellac varnish evenly on it. Now sprinkle some brass, or other metal, filings on it and then lay a strip of tin-foil on each end of the glass, so that they will make contact with the filings, and let the shellac dry. Connect the strips of tin-foil to the spark-gap electrodes, as shown at *E*; this done, press down on the key and the sparks will jump zigzag over the filings.

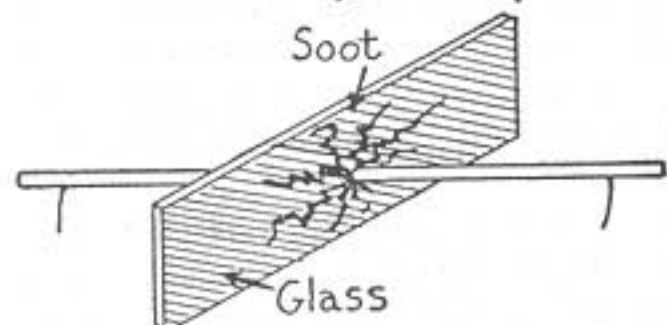
How to Make a Lightning Board.—Cover a smooth pine board or the bottom of a cigar box with shellac varnish and lay a strip of tin-foil one inch wide and six inches long on it, then rub it out smooth and let it dry. Now, with the point of a sharp knife cut the tin-foil into one-eighth inch squares. Connect the ends of the tin-foil strip with the binding posts of your spark coil, as shown at *F*, and then press down on the key, when the sparks will travel in various paths like so many little streaks of lightning.

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How to Make an Electric Spark Sign.—You can make the spark form any word you want by cutting



A: An Electric Spark Sign



B: An Autograph of an Electric Spark

Fig. 150. Two Curious Electric Spark Effects.

the word out of a sheet of tin-foil and fixing it to a perfectly dry board with shellac, as shown at *A* in *Fig. 150*. The sparks jumping across the minute gaps between the adjacent squares of tin-foil, produce the word in brilliant flashes when you perform the experiment in a dark room.

Making the Electric Spark Sign Its Name.—When you make the high potential electric current of a spark coil jump between the pointed electrodes and a surface that is a good conductor, it forms a tree-

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like image that is both realistic and pretty. This image is the signature, or autograph, of the electric spark.

To obtain such an autograph, rub a wee drop of kerosene on a sheet of glass about one inch wide and three inches long, and then smoke it over the flame of a candle. Set the points of your spark coil about one-eighth or one-quarter inch apart and hold the smoked glass between them, as shown at *B*, when sparks will radiate from them all over it in every direction. If you will look at the autograph with a low power microscope, you will see exactly how the sparks acted on it.

Making a Photograph of an Electric Spark.—Another and more permanent way to get a record of the image of an electric spark is to set up your spark coil in a photographic dark room. Then under a red light take a three and one-quarter by four and one-quarter dry plate, such as is used for making negatives, from the box and hold it between the pointed electrodes of the spark coil for half a minute or so; now *develop* and *fix* the plate in the usual way, when you will have a lasting record of the spark.

Pulling the Spark Out of Its Path.—Hold the flame of a candle near the spark of your spark coil, when it will be attracted to it, as shown in *Fig. 151*. This is due to the fact that the heated air around the flame is a better conductor than the cooler air farther away.

How to Get Sparks from Water.—Fill a glass tumbler nearly full of water, connect a wire to one of the binding posts of your spark coil and let the other end dip into the water. Connect another wire to the

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other binding post of the spark coil and fix its free end to the edge of the glass so that it will come to within one-sixteenth inch of the surface of the water, as shown at *A* in *Fig. 152*. Now press down on the key, when a bright spark will jump between the water and the end of the wire.

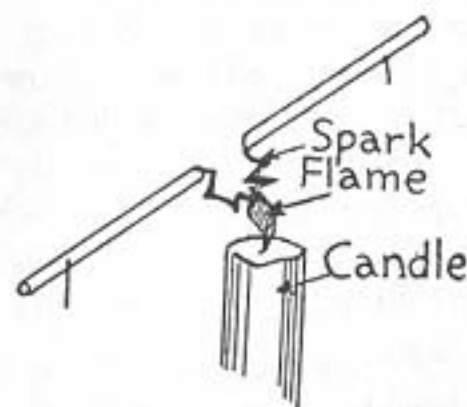


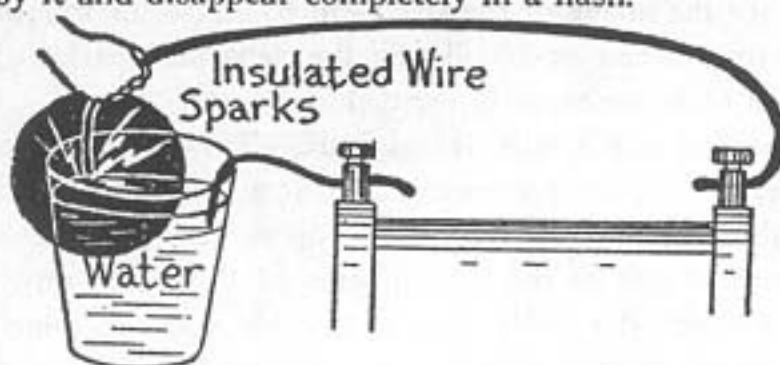
Fig. 151. Pulling the Spark Out of Its Path.

Lighting a Gas Jet With an Electric Spark.—When the pointed electrodes of the spark coil are brought close together, quite a hot spark is produced and this will ignite gas, paper, lycopodium, guncotton, and other easily inflammable substances. To light a jet of gas by means of an electric spark, separate the pointed electrodes of your spark coil about one-sixteenth inch and hold the coil close to the gas jet, as shown at *B*. Now press down on the key and the spark will light the gas.

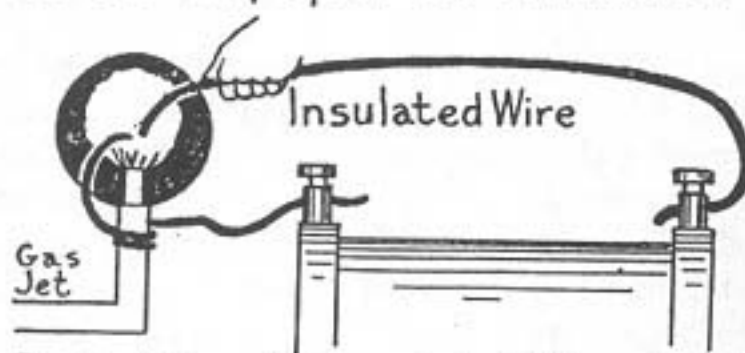
Lighting Paper With an Electric Spark.—Hold a bit of very dry tissue paper between the electrodes forming the spark gap, press down on the key, and the paper will ignite. Lycopodium comes in the form of a powder, and this can be ignited by placing a pinch

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of it on a card and holding it between the pointed ends of the spark-gap electrodes. A bit of guncotton held on a toothpick in the path of the spark will be ignited by it and disappear completely in a flash.



A: Getting Sparks From Water



B: Lighting A Gas Jet With a Spark

Fig. 152. Two More Good Experiments.

Analyzing the Spark in a Swinging Mirror.—While the eye sees the electric discharge that passes between the spark-gap points as a single continuous spark, it is really made up of a number of separate and distinct sparks. To analyze the discharge and see it as a succession of sparks, tie a couple of threads around a mirror one inch wide and three inches long.

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Support it by tying the free ends of the thread together and loop them over a book that projects a little from a pile of others, as shown in *Fig. 153*, and

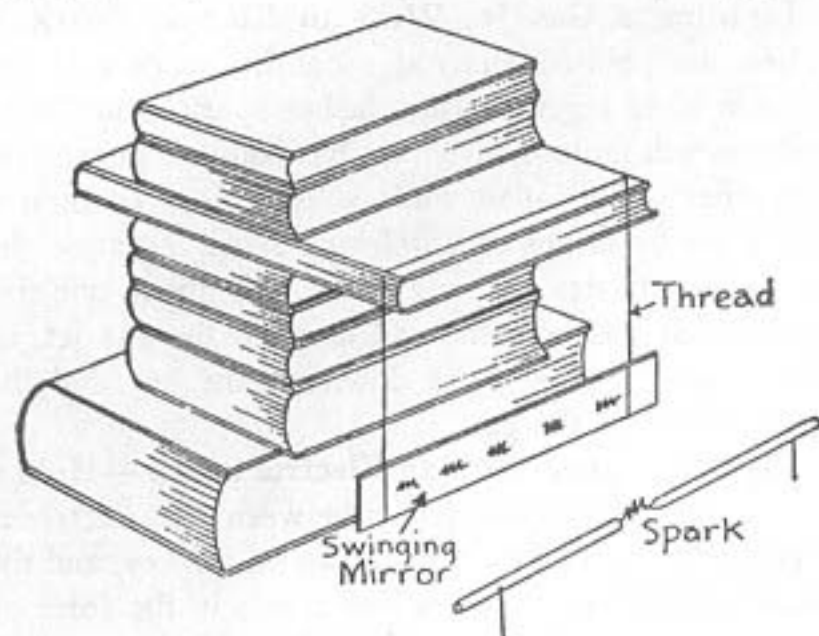


Fig. 153. Analyzing the Electric Spark.

see to it that the mirror swings to and fro freely and evenly. Now set your spark coil up in front of the mirror so that when you press down on the key you can see the image of the sparks in it. Give the mirror a swing, when you will see the separate sparks of which each discharge is formed.

Making the Earth Stand Still.—This caption exaggerates the facts somewhat. Cut a disk out of stiff cardboard about three inches in diameter, and draw a picture of one of the hemispheres of the world on it. Now rotate it rapidly, and to do this you can punch a hole in the center of it and put it on the shaft of a small motor, as described in Chapter X.

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Or you can punch two small holes near to and on opposite sides of the center of the disk, and run a double string about two feet long through them. Now, by twisting up the strings and then pulling on them to make them unwind, then slacking up a little on them until they wind up on it again the other way, and pulling on it again, the disk will rotate first in one direction and then in the other.

Set your spark coil so that the spark will take place

just in front of the rapidly rotating disk, and then have your chum press down on the key. Every time a spark takes place the picture of the world you have sketched on it will appear to be stationary, provided the disk makes one complete revolution in the same length of time that intervenes between any two successive sparks. This experiment shows that the electric spark is practically instantaneous.

The Radial Disk Experiment.—In Chapter X we explained under the lurid caption of "The Prohibition Jag-o-scope" how to make a radial disk. Now, by spinning this disk either by means of a motor or by twisting and untwisting a string loop, the same effect described in the foregoing experiment can be performed with even more striking results.

That is to say, when you make a spark take place in front of the rotating disk, the radial bars on it will appear to be stationary if the rotation of the disk and the successive sparks are *synchronous*, that is, if they take place at identically the same times. By making the disk rotate faster, or by slowing down the time period of the vibrator of your spark coil, the bars on the disk will seem to turn slowly backward.

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By making the disk rotate slower or increasing the interruptions of your vibrator, the bars on the disk will seem to turn slowly forward. Finally, a speed may be had where one of the sets of radial bars will apparently turn to the right and the other set of bars will seem to turn to the left. All of these effects are due to the fact that the electric spark is practically instantaneous.

The Rainbow Colors.—Make the disk described under the caption of "The Colors of the Spectrum," in Chapter X, and either mount it on the shaft of a small motor, or, lacking this, make a buzz wheel of it, as described under the caption of "Making the Earth Stand Still" in this chapter, and rotate it in front of the spark of your coil. Now, when it gets up to speed, the colors will merge into each other, and the disk will apparently be white; but every time you press down on the key and a spark passes, you will see each color stand out distinct and perfectly still. This experiment also shows that the electric spark is almost instantaneous.

What a Geissler Tube Is and Does.—The most brilliant and beautiful experiment that you can perform with a spark coil is lighting up a *Geissler tube*. A Geissler tube is a tube with a wire electrode sealed in each end, and from which the air has been pumped

out and a slight trace of gas has been admitted when the tube is sealed off.

¹So called because it is named after its originator Heinrich Geissler of Germany. Born 1814, died 1879.

When the electrodes of the tube are connected with the spark gap of a spark coil, the tube will glow with

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a soft radiant light, the color of which depends on the kind of gas that is in the tube and also the glass of which the tube is made. Further, the light in the tube is *stratified*, that is, broken up into separate parts or strata, and it is cold like that produced by the firefly. One form of Geissler tube is shown in Fig. 24 in Chapter II.

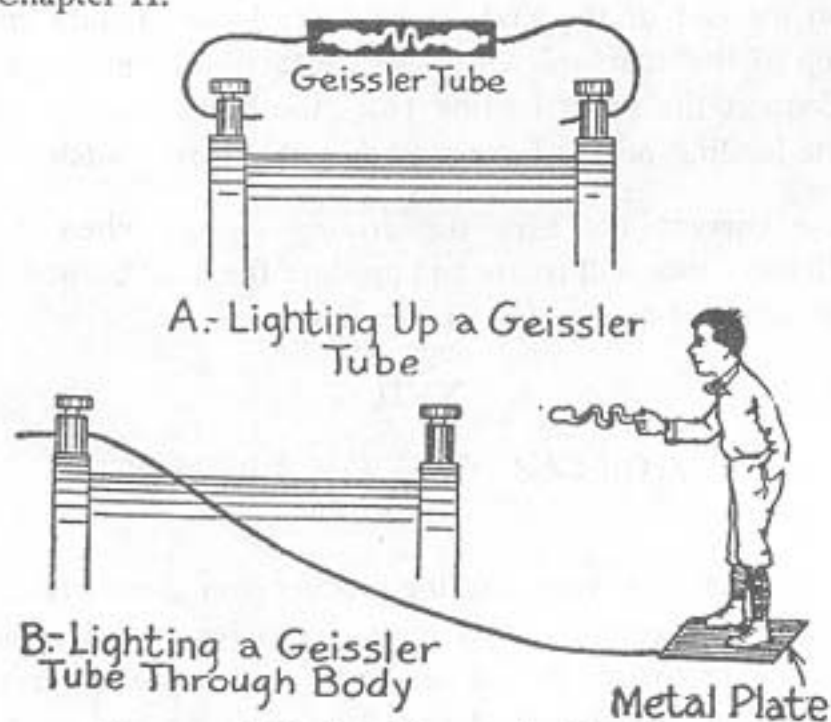


Fig. 154. A Couple of Spectacular Experiments.

How to Light Up a Geissler Tube.—Connect up the electrodes of the Geissler tube to the binding posts of your spark coil, as shown at A in Fig. 154, and close the battery circuit either with a key, or by screwing up the contact points, when the tube will be beautifully illuminated. Two or more tubes can be connected to-

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gether and the end electrodes connected with the spark coil, when they will all be illuminated, as the amount of current required to energize them is very little.

Lighting a Geissler Tube Through Your Body.—Connect one of the binding posts of your spark coil with a sheet of tin, copper, or zinc, lay it on the floor, and stand on it. Now hold a Geissler tube by one of its electrodes close to, but not touching, the other binding post of your spark coil, as shown at B. Now set your spark coil into action and the tube will light up.

Transmitting Electricity Over a Single Wire.—

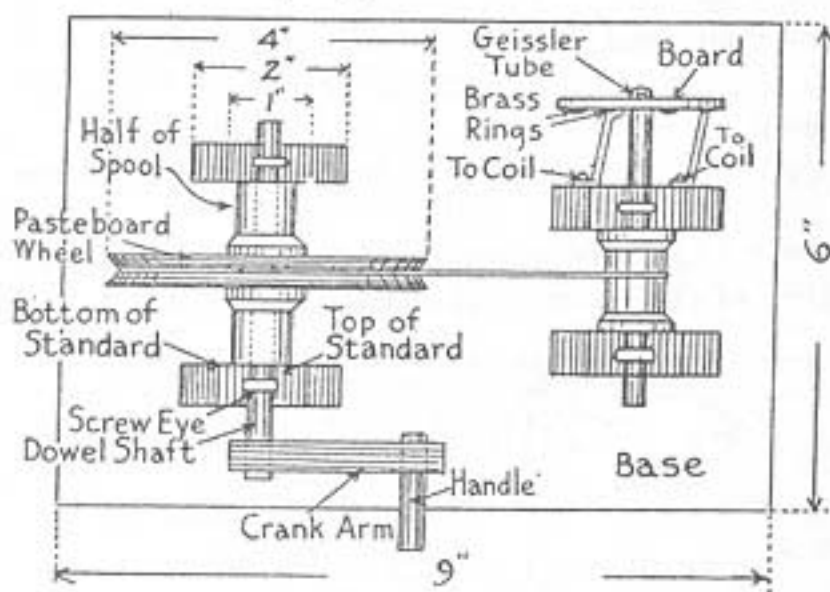
Remove the metal plate from the end of the wire and connect the wire with one of the electrodes of the Geissler tube; hold the other electrode in your hand; now you turn on the current, when the tube will light up as before, but not so brightly.

The Whirling Geissler Tube.—One of the prettiest effects in the whole realm of experimental electricity is had when a Geissler tube is illuminated and then rotated. When the tube makes one complete revolution every time the vibrator makes and breaks the current, the tube will appear to be standing still. If the tube makes one and a fraction revolutions every time the current is made and broken, it will appear to be turning very slowly forward, while if it rotates slower than one revolution every time the current is made and broken, it will appear to be turning slowly backward.

How to Make a Geissler Tube Rotator.—If you have a small motor, it is easy to arrange the Geissler tube so that it will rotate, but if you haven't one you

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can make a hand rotator in the following manner: Get a board for a base one inch thick, three inches wide and ten inches long. Make a grooved pulley one-quarter inch thick and three inches in diameter by gluing a number of pasteboard disks together, and cut a one-quarter inch hole in the center of it. Saw, or cut, an ordinary spool in two and glue the cheek side of each half to the opposite sides of the pulley, as shown at A in Fig. 155.



A: Top View of the Rotator

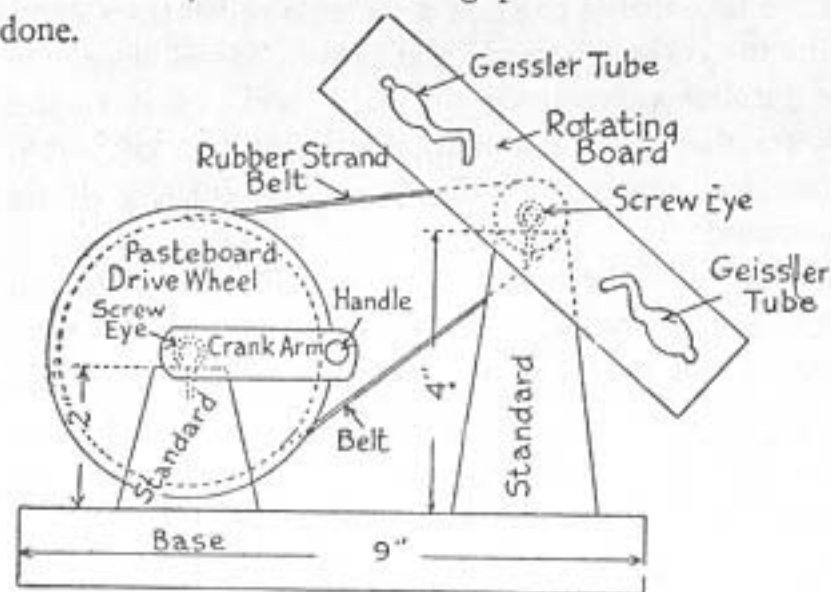
(A) Fig. 155. A Rotator for a Geissler Tube.

Now take a piece of dowel one-quarter inch in diameter (this you can get at a carpenter shop or a lumber yard), smear a little glue on the middle of it, and slip the pasteboard pulley and half-spools onto it.

Next, make two standards one-half inch thick, two inches wide and four inches high, and screw a one-quarter inch screw-eye in the top of it, as shown at B.

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This done, cut a groove round the middle of a spool, and glue it on a piece of one-quarter inch dowel, three and one-quarter inches long, slip the ends of this shaft through the screw-eyes of the two other standards; glue and screw these to the base-board, and it is a good scheme to brace them with an angle block on each side. Tie a piece of soft string around the grooved pulleys for the belt, and the rotating part of the rotator is done.



B- Side View of the Rotator

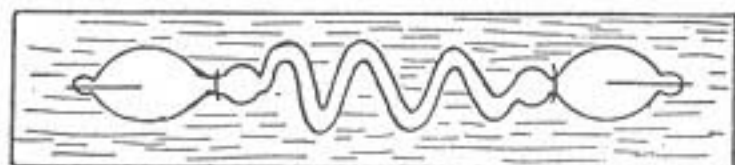
(B) Fig. 155. A Rotator for a Geissler Tube.

The next and last thing to do is to make the brushes, which carry the current from the spark coil to the Geissler tube when it is rotating. Cut out two brass strips, each about one-quarter inch wide and two inches long, and screw these on top of one of the standards, as shown at A, and bend over the ends of each one.

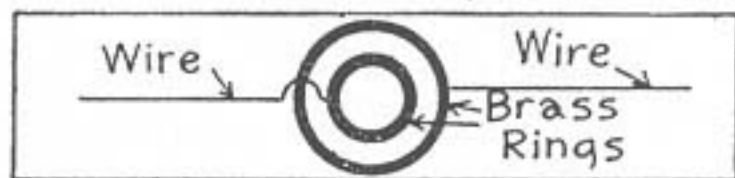
To conduct the current from the brushes to the

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Geissler tube when it is rotating, mount the latter on a strip of cigar box wood about two inches wide and



C- Front of Rotating Board



D- Back of Rotating Board

(C-D) Fig. 155. How the Rotating Element is Made.

seven inches long; cut a one-quarter inch hole in the center of it and then fix two flat rings, which you can cut out of sheet brass, to one side of it, as shown at C and D.

Solder a wire to each ring and bring the one from the inside ring up and over the outside ring, then over to the hole in the board and through it, when you can fasten it to one of the terminal rings of the Geissler tube on the other side. Bring the wire from the outside ring over to the other hole in the board, then through it, and fasten it to the other terminal ring of the tube.

Finally, slip the board with the Geissler tube on it, on the end of the shaft so that the brass brushes on top of the standard will make contact with the rings. Connect the wires leading from the brass brushes to the binding posts of your spark coil. Now switch on

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the current and turn the driving pulley, when the Geissler tube will rotate and produce the most beautiful illuminated color effects imaginable.

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XVII

MOTOR-CAR IGNITION, LIGHTING AND STARTING

IN these days of gasoline engines you should be at least on speaking terms with electricity, and if you own a motor-car it will be worth your while to learn something about how the ignition, lighting and starting systems work. To look at the electrical equipment on a car without having learned about the different parts of it first, is like looking at a pile of the pieces of a jig-saw puzzle, only the former is much harder to solve than the latter. A careful reading of this chapter will, however, enable you to separate the different components and know them when you see them in a car, and this will help very greatly to clarify the subject in your mind.

About Ignition Systems in General.—When the gasoline and air mixture, or *fuel mixture*, as it is called, is compressed in the cylinder of an engine, some means must be used to fire it. On all motor-car gasoline engines an electric spark is used to fire the *fuel charge*, as the compressed fuel mixture is called. To set up the spark, a high voltage current, or *high tension current*, as it is generally termed, is used and this is set up by one of three different kinds of apparatus, which named are (1) an ordinary *spark coil* with a *vibrator*; (2) a *magneto*, which is a small dy-

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namo electric machine, and (3) a *spark coil* with a *circuit-breaker*.

How the Vibrator Spark-Coil System Works.—The apparatus for a vibrator spark-coil system consists of: (1) a *battery*, (2) a *spark coil* with a *vibrator*, (3) a *timer*, or a *distributor*, and (4) a *spark plug*.

The Battery.—This can be either, (a) one made up of *dry cells*, or (b) one of *storage cells*, and both of these kinds have been explained in Chapter III. Since nearly every motor-car that is made at the present time is provided with a storage battery for lighting and starting, this is generally used for energizing the spark coil of the ignition system; but where a car is provided with only a spark-coil ignition system—that is, where it is not equipped with a magneto also—it is a good scheme also to provide a dry battery.

The Vibrator Spark Coil.—This coil is simply an ordinary spark coil like the one described in Chapter XV, but it is enclosed in a box, instead of being mounted on a base, and it is smaller, giving a spark about one-half inch long. The vibrator is worked magnetically, that is, by the magnetization and demagnetization of the core of the coil. It is energized by either a dry cell battery or a storage battery.

The Strokes of a Four Cycle Engine.—Now, before we go on with a description of the apparatus, you must know the principle a gas engine works on. Each cylinder of a motor-car engine has only one effective, or power stroke in four, and for this reason this type

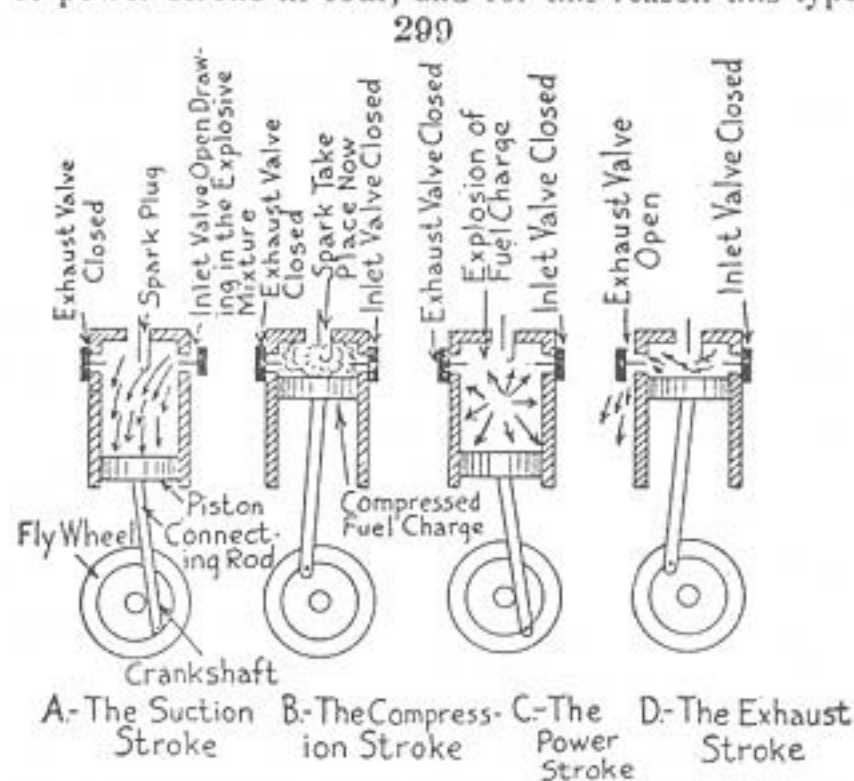


Fig. 156. How a Single Cylinder Four Stroke Cycle Engine Works.

of engine is called a four-stroke cycle engine.

The *first stroke* of the piston draws in gasoline mixed with air, or *fuel mixture*, as it is called, and this is termed the *suction stroke*; the *second stroke* of the piston compresses the fuel mixture in the cylinder, and this is called the *compression stroke*; at this instant the electric spark fires the compressed fuel mixture, or *fuel charge*, as it is now termed, when the explosion of the gases of which it is formed drives the piston forward, and this is the *third*, or *power stroke*; and, finally, the *fourth stroke* forces the burnt gases out of the cylinder, and this is called the *exhaust stroke*. These strokes are shown diagrammatically in Fig. 156.

The Spark Plug.—To make the spark take place in the head of the cylinder and ignite the fuel charge, a *spark plug* is used. This little device, which is shown in cross-section at A in Fig. 157, and ready to use at B, consists of (a) a wire, called the *central electrode*, on one end of which is a binding post, and having on the other end a platinum wire, or other metal wire that has a high melting point.

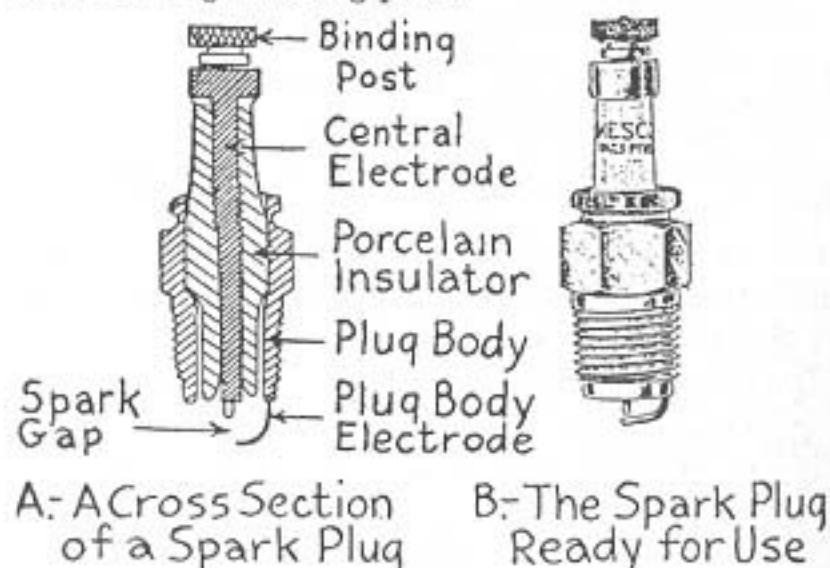


Fig. 157. How the Spark Plug is Made.

This electrode is sealed in (b) a porcelain tube which insulates it from (c) a threaded brass tube called the *plug body*, and to this is secured (d) another platinum, or other metal, wire. The points of these electrodes come very close to each other and so form a minute *spark gap*. The plug body is threaded and this permits the plug to be screwed into the head of the cylinder of the engine.

From this construction it is clear that when the plug is screwed into the cylinder the spark gap is inside of the latter, and the binding post is outside of and insulated from it. When the plug is connected to the other parts of the ignition system, a wire from the

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binding post forms one of the leads, while the engine itself forms the other lead.

The Timer and the Distributor.—The Timer.—As you know, if you connect the primary coil of your spark coil directly to a battery and start the vibrator going, a continuous stream of sparks takes place in the spark gap, and if, under these conditions, the secondary coil of the spark coil was connected with the

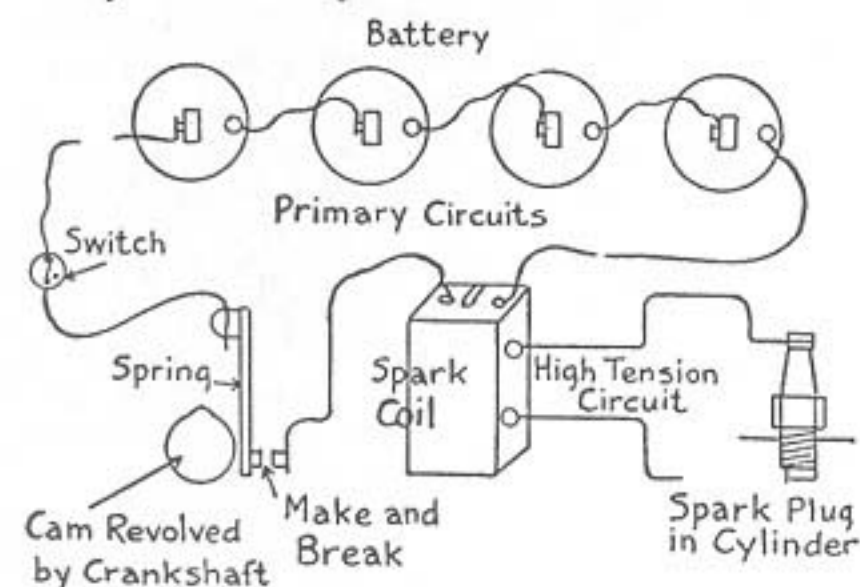


Fig. 158. How the Timer for a Single Cylinder Four Stroke Cycle Engine Works.

spark plug, the sparks would fire the fuel mixture as soon as the suction stroke begins to draw it in. It is evident, therefore, that the spark must take place at the precise moment when the ignition of the fuel charge will give the greatest explosive power. To do this in a single cylinder engine, a *timer* is used, and where an engine has two or more cylinders, a *distributor* is used. A distributor is really a timer, too, but it is so called to differentiate it from the device used for a single cylinder engine.

How a Timer Works.—Now let us take a single cylinder, four-stroke cycle engine and see just how the battery, the spark coil, the spark plug and the timer are connected up and how they work. The timer, as you will see in the diagram in Fig. 158, consists of a *cam*, that is, a projection, on a wheel, or shaft, that is rotated by the crankshaft of the engine.

Fixed to the body of the engine, but insulated from it, is a *spring make-and-break contact*, or *contact-breaker*, as it is called, and the free end of the spring, to which is fixed one of the contact points, presses on the cam wheel, or shaft. Now, every time the crankshaft makes two complete revolutions, which is equal to four strokes of the piston, the cam wheel, or shaft, revolves once, and, hence, the cam strikes the spring once in every four strokes of the piston.

When it does so it presses the spring over until the point that is on it makes contact with the fixed point, and this closes the primary circuit; the battery then energizes the coil and the spark takes place in the spark gap of the spark plug.

The Distributor (shown at Fig. 159).—This device consists of a ring, or a block, of insulating material, and on the inside of, or around, which there are as many fixed contact points as there are cylinders to be fired. Each of the contact points is connected with a binding post; inside of the ring of the fixed contact points is a rotating contact arm, and this is

driven by a shaft which is geared to the crankshaft of the engine.

Now, let us suppose that the engine has four cylinders, in which case four spark coils must be used, and one of the wires from each of the primary coils is connected with its respective post of the distributor, while all of the other wires of the primary coils lead to one post of the battery, and the other post of the battery is connected with the rotating contact arm.

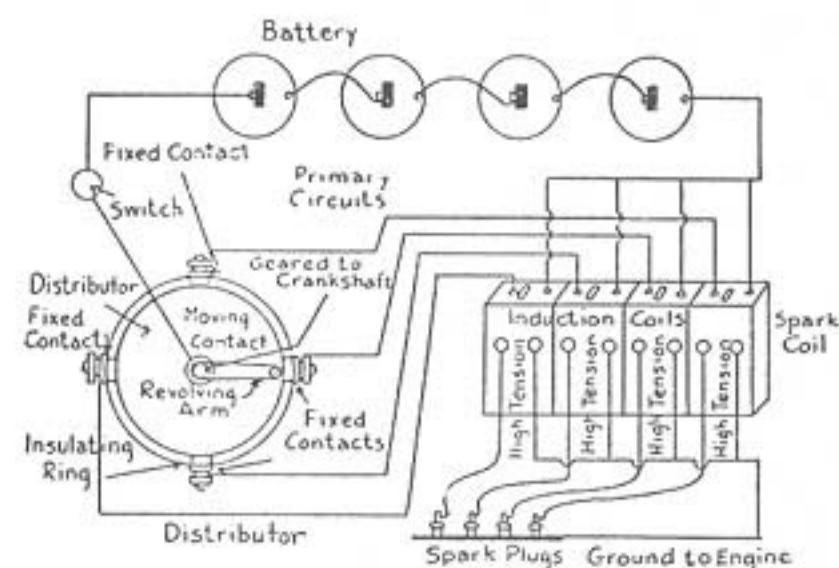


Fig. 159. How the Distributor for a Four Cylinder, Four Stroke Cycle Engine Works.

Finally, one of the wires of each of the secondary coils is connected with the post of its complementary spark plug, and all of the other wires of the secondary coil are connected with the body of the engine, or are *grounded*, as this kind of a connection is called, so that they are really connected with the spark-gap points that are fixed to the plug bodies.

Now, when the engine is running and the contact arm is rotated, it strikes each of the fixed contacts in turn and so closes the primary circuits of the coils one after the other. The points of contact are so timed that at the instant the piston of each cylinder has com-

pleted its compression stroke, a spark takes place in the spark gap of the spark plug and fires the fuel charge.

How the Magneto Works.—The next improvement in ignition systems to follow the vibrator spark coil was the magneto. This generator consists of an armature rotating between the poles of a powerful, permanent steel magnet. Now, there are two kinds of magnetos, and these are (1) the *low tension* magneto and (2) the *high tension* magneto.

In the low tension magneto (See *A* in Fig. 160)

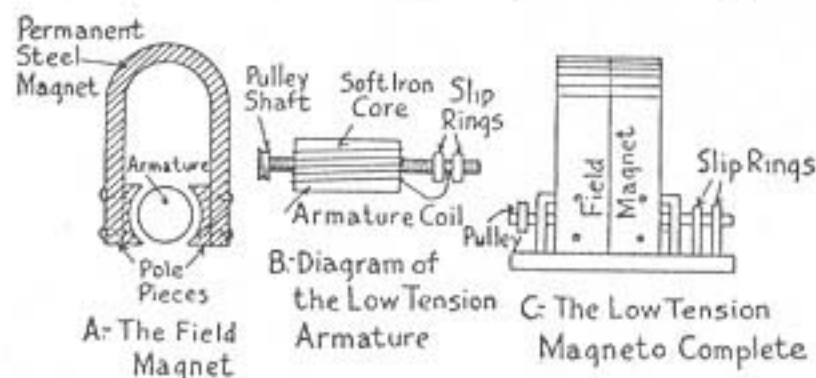


Fig. 160. The Low Tension Magneto.

the armature is wound with a single coil of wire only, and when it is rotated in the magnetic field it generates a low voltage alternating current. This is led to a spark coil, which it energizes just as a dry cell or storage battery does. The armature of the magneto is usually driven by the pump shaft or cam shaft of the engine. The Ford magneto is of the low tension

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type, but its design is different and its armature is connected direct to the crankshaft of the engine.

In the high tension magneto the armature is wound with two coils of wire, namely, a *primary coil* and a *secondary coil*, and it is really a rotating spark coil. As the armature revolves, low tension currents are set up in the primary coil by the turns of wire cutting the magnetic lines of force, and these induce high

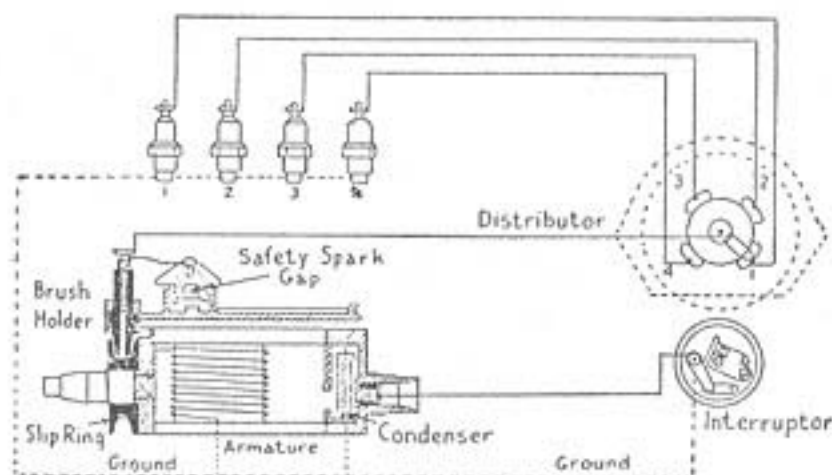


Fig. 161. Wiring Diagram of the High Tension Magneto With Interrupter and Distributor.

voltage, or high tension, currents in the secondary coil just as they do in an ordinary spark coil.

An interruptor, or *circuit-breaker*, as it is called, which is worked by the pump or cam shaft, is connected in circuit with the primary coil and a condenser, which is placed in one end of the armature, is shunted around the contact points. A wiring diagram of a high tension magneto with its interruptor, or *circuit-breaker*, and distributor, is shown in Fig. 161.

How the Circuit-Breaker Spark-Coil System Works.—When electric lighting and starting came

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into vogue, every car so equipped had to carry a storage battery to supply the necessary current, and having ample current at hand it was the most natural thing in the world to use it for ignition purposes. This being the case, and since the magneto is an expensive piece of apparatus, the *circuit-breaker spark-coil system* was devised.

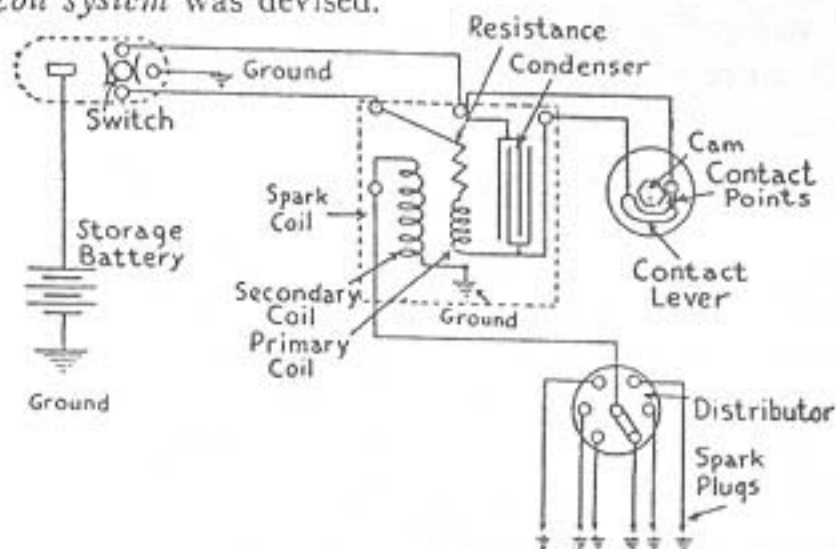


Fig. 162. Wiring Diagram of the Circuit Breaker Spark Coil System.
(For a Six-Cylinder Engine.)

This system consists of: (1) a *single spark coil* made like an ordinary spark coil, but without the vibrator on it, and which is energized by the storage battery; (2) a mechanical interruptor, or *circuit-breaker*, like that used with the magneto, and which is driven by the pump or cam shaft of the engine, and (3) a *distributor*, all of which are shown in the wiring diagram in Fig. 162.

The circuit-breaker is formed of a cam made in the shape of a nut, and this has as many corners on it as there are cylinders to be fired. The contact arm of the distributor is fixed to the free end of the shaft, while the stationary plate that carries the fixed contacts is held in place so that the arm revolves on or close to it. Both the circuit-breaker and the distributor are mounted in an insulating cover, or *housing*, as it is

called, and together they form what is called an *ignition head*.

How the Electric Light System Works.—The lighting system of a motor-car is formed of three principal parts, and these are (1) the *storage battery*, (2) the *dynamo* to charge it, and (3) the *automatic cut-out*. Storage batteries are made for different voltages, but most of the makes of cars use a *6-volt* battery. The storage battery, as you know, must be recharged, and to do this a small direct current generator, or dynamo, which is driven by the engine, is used.

The reason an automatic cut-out must be used is this: When the engine is running at its normal speed the dynamo develops a higher voltage than the storage battery does, and then the current from the former flows into the latter and charges it. On the other hand, when the engine is running slowly it develops a lower voltage than the storage battery, in which case the current from the latter would flow into the former and run it as motor, thus wasting its power. To prevent this, an automatic cut-out is connected in the circuit between the storage battery and the dynamo, so that when the latter is developing a higher voltage than the former, the cut-out closes the circuit, and

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when the former is developing a higher voltage than the latter, the cut-out opens the circuit.

The automatic cut-out consists of a pair of platinum contact points, one of which is fixed and the other one is mounted on a spring, and it is, therefore, movable, like the vibrator of a spark coil. Like the vibrator, too, the spring is worked by an electro-magnet, and these are connected in circuit between the dynamo and the storage battery.

A second pair of contact points called the *regulator points* are also included in the circuit, and these are likewise controlled by another electro-magnet. When the contact points are separated, a *resistance* is connected in the circuit of the field coil of the dynamo; when this takes place, the current generated by the dynamo must flow through the resistance and this limits the amount that can flow into the storage battery. This scheme prevents the dynamo from overcharging the battery. The way the battery, the dynamo, the automatic cut-out, the regulator contact points and the lamps are connected in circuit, is shown in the wiring diagram in *Fig. 163*.

Kinds of Wiring Systems.—There are two different schemes used for wiring motor cars, namely,

(1) the *single wire* system and (2) the *two wire* system. In the first named system a single wire only is needed for the return circuit, which is made through the frame of the car; this scheme, which is shown in *Fig. 164*, is called the *grounded system*.

In the second system two wires are used, and both of these are insulated from the frame of the car. Whichever kind of wiring system is used, the lamps

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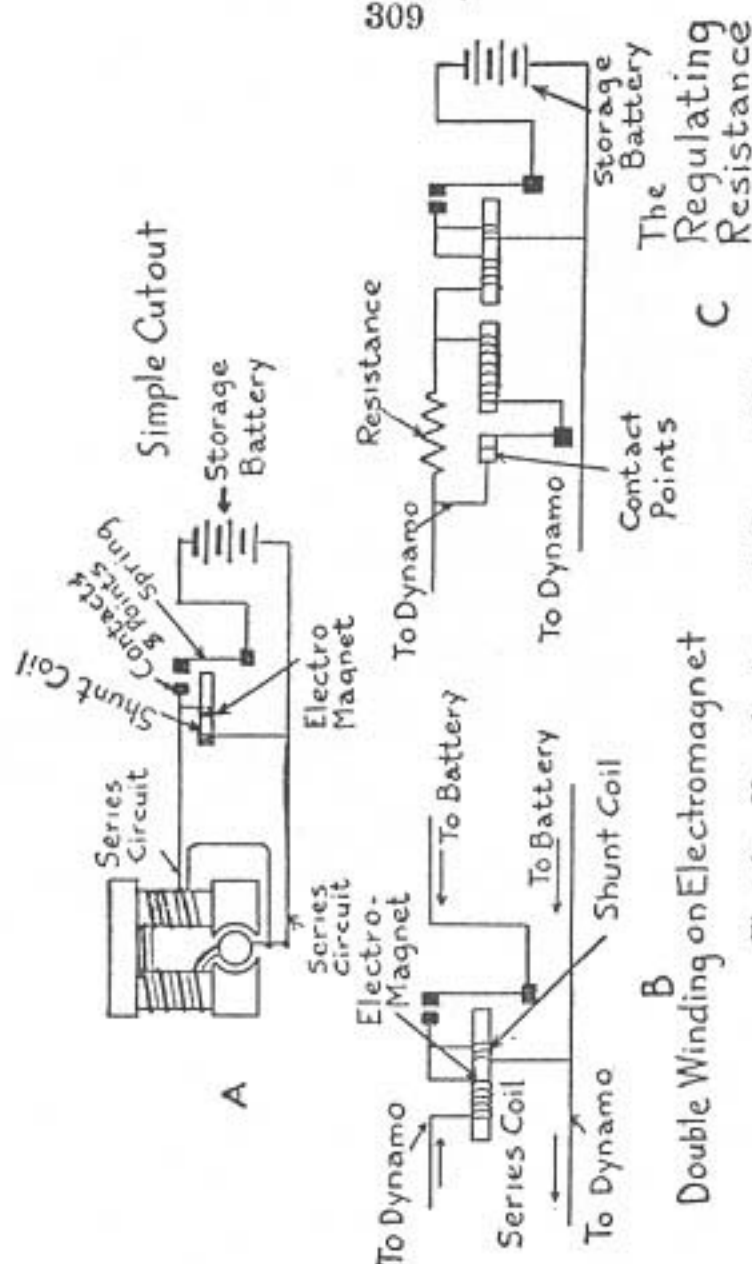


Fig. 163. How the Automatic Cut-out Works.

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are connected up in parallel, that is, across the feed wires. This not only enables a low voltage current to be used but, what is equally to the point, if one lamp burns out the others are not affected by it as they would be if they were connected in series.

How the Electric Starter Works.—The electric starting system consists of four chief parts, and these are (1) the *storage battery*, (2) the *electric motor*, (3) the *electric drive*, and (4) the *starting switch*. Since you know how the battery, the motor and the switch work, the only part you need to learn about is (1) how the starting motor is connected with the

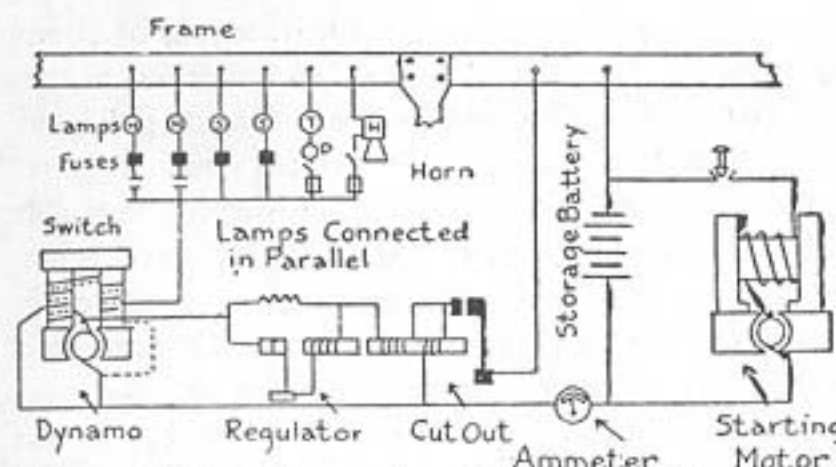
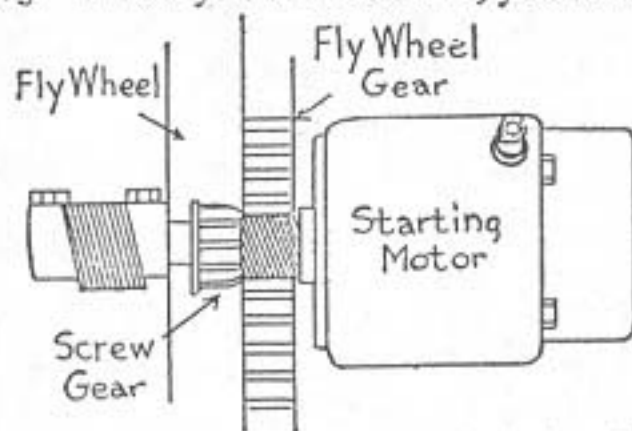


Fig. 164. Wiring Diagram of a Single Wire Lighting System. engine when you press down on the starting switch, and (2) how the motor is disconnected from the engine after it has started it.

As the *Eclipse-Bendix drive* is used on a large number of cars, we will describe it as a typical starter. The rim of the flywheel of the engine has teeth cut in it so that it is, in fact, a big gear, and the shaft of the motor has a small gear on it, which meshes and

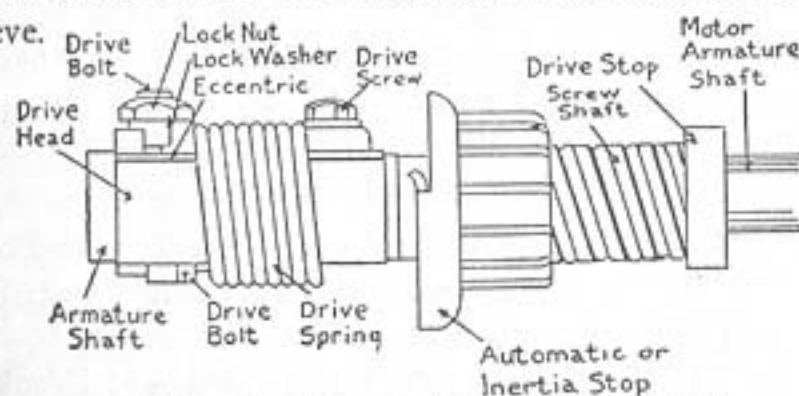
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demeshes with the flywheel gear, as shown at *A* in Fig. 165. If now you will look at *B*, you will see that



(A) Fig. 165. The Starter and Fly-wheel of an Engine.

the drive consists of a sleeve with screw threads cut on it, and this is slipped over the shaft of the motor. The sleeve is fastened to the shaft of the motor by means of a strong spiral spring, one end of which is bolted to the shaft and the other end is screwed to the sleeve.



(B) Fig. 165. How the Motor Drive is Made.

The small gear has threads cut on the inside of it, so that it will screw on the threaded sleeve like a nut,

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and, moreover, it is weighted on one side. Since this gear can screw to and fro on the shaft, it is evident that when it is at one end of the latter it will mesh with the flywheel gear, and when it screws along the shaft it will demesh from the latter. This is all there is to the drive, and now let's see how it works.

The first thing to learn is what the action of the drive is when it starts the engine. By referring to *B*, you will observe that the gear on the threaded shaft of the motor is demeshed from the flywheel gear of the engine. When, now, you press down on the starting switch, the circuit connecting the battery and the motor are closed and the threaded shaft of the motor soon gets up to speed.

The small gear on the shaft does not, however, rotate with the shaft, for the weight on it keeps it from doing so, with the result that it screws its way to the outer end of the shaft until it reaches the end, when it meshes with the flywheel gear. Having reached the end, it must, of course, turn with the motor shaft, and hence it turns the flywheel, which is keyed to the crankshaft of the engine.

Once the engine is started the speed of the periphery of the flywheel gear is so much faster than that of the threaded shaft, the small gear gradually begins to screw its way back toward the motor and so moves out of mesh with the flywheel gear. When this takes place you release the switch, when the motor stops and the small gear is in its original position ready for the next starting.

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XVIII

THE DISCOVERY AND USE OF THE X-RAYS

How the X-Rays Were Discovered.—While experimenting with a Crookes tube¹ Wilhelm Roentgen discovered the "X-rays," or as they are also called, Roentgen Rays. It was on November 8th, 1895, that this German professor first saw the new and unknown rays, or, rather, the effects of them, but he did not make his observations public for several months. On that first memorable day, in his laboratory at the University of Wurzburg, Bavaria, he noticed a faint, flickering, greenish light upon a piece of cardboard, which he had painted over with a fluorescent chemical compound, and upon the faintly luminous surface was the shadow of a line. This strange effect took place in a perfectly dark room, from which every known kind of ray had been carefully shut out. But in that

room a Crookes tube, energized by a spark coil, was in action, and although the former was entirely covered with black cardboard and the sparks of the latter were also shielded so that not even the feeblest ray of light could get through from either of them, still the fluorescent chemical compound was made luminous.

³¹⁶A modified form of Geissler tube.

This strange phenomenon led Prof. Roentgen to suspect that a hitherto unknown kind of ray was emanating from the Crookes tube, and a further examination showed that this was really the case;

316 further, and more wonderful still, that it had the power to pass through certain material objects which were opaque to light, and on striking a fluorescent screen to make it luminous.

Roentgen's Further Investigations.—After he had observed that the fluorescent screen had become luminous by the bombardment of the invisible rays and the shadow of a line across it, the work of tracing that shadow to the object which produced it, and to verify the source of the rays to the Crookes tube was to the trained physicist but the work of a few minutes. Further investigation on Prof. Roentgen's part showed that the invisible rays had a marvellous power of penetration; he found that they would go through cardboard, cloth, wood and some other substances, but the metals, such as gold, silver, copper, iron and lead, were less penetrable, and some of them, as, for instance, lead, were practically opaque. But, strangest of all, while the flesh of animals was very transparent, their bones were fairly opaque; and so when the discoverer held his hand between the source of the rays and the fluorescent cardboard screen, he saw the shadow of the bones of his hand projected upon it. Not knowing what the nature of the new rays was, he called them *X-rays*, since *x* in algebra represents an unknown quantity. After he had made sure of his facts, he gave his secret to the world early in 1896.

Various Uses of the X-Rays.—The far-reaching importance of Prof. Roentgen's discovery was immediately recognized, and there was scarcely a branch of science in which it did not open up new paths of research. To the medical profession it meant a wonder-

317 ful advance in diagnostics, since certain disorders which had before been possible to examine only from the outside of the body could now be projected upon a screen, or photographed on a plate, and seen with the eye.

During the late Great War, thousands of lives were

saved by the use of the X-rays, for by means of X-ray photographs, or *radiographs*, as they are called, bullets and pieces of shell could be located with precision, while the extent and nature of broken bones were revealed, and with this knowledge the surgeon was able to act with certainty. In the diagnosis of various diseases, the X-rays are of the greatest value, and every hospital in the country now has an X-ray outfit as a part of its necessary equipment. The X-rays have played an important part in physics, especially in the study of the structure of the atom, while in the industries it has proved of great value in the quick detection of hidden flaws and impurities in the products that are turned out; further it is of great service to the customs' officers, who use it with telling effect when searching for contraband; while, finally, it has many curious uses, as, for instance, in pearl fisheries, the oysters being examined by the X-rays instead of having to be opened, and those without pearls are returned to the beds uninjured.

The Apparatus for Producing the X-Rays.—In its simplest form the apparatus needed for generating the X-rays includes: (1) a battery, or other source of current; (2) a spark coil; and (3) a Crookes tube, or X-ray tube, as it is now generally called. To make the invisible rays manifest themselves, you will need

318 (4) either (a) a fluoroscope or (b) a photographic plate.

The Source of Current.—The current for energizing the X-ray tube can be had from either a battery of primary cells, a storage battery, or a direct current from a lighting circuit. Where an alternating current only is available, a high potential transformer, like that employed in wireless spark transmitting sets, must be used instead of the ordinary spark coil.

The Energizing Apparatus.—While you can use a very small X-ray tube with the two-inch spark coil, described in Chapter XV, if you wish to get really practical results you need a coil that will give a four-inch spark at least, while a one-quarter kilowatt transformer will serve where an alternating current must be used. Finally, you can get very good results by using an electrostatic machine of the Toepler-Holtz or Wimshurst kind, and these you will find described and pictured in Chapter I.

The Crookes, or X-Ray, Tube.—A Crookes tube differs from a Geissler tube, which has been described in Chapters II and XVI, in that it has (a) a spherical or oval shape, instead of a tubular shape,

and (b) the air is pumped out of it to a much higher degree. A Crookes tube in its simplest form has a pair of wire electrodes sealed in it, which serve to carry the current into and out of the bulb.

The kind of Crookes tube made use of by Prof. Roentgen is shown at A in Fig. 166. As the X-rays set up by this kind of a tube are diffused, that is, they spread out from it in all directions, various kinds of tubes have been devised which would project the rays

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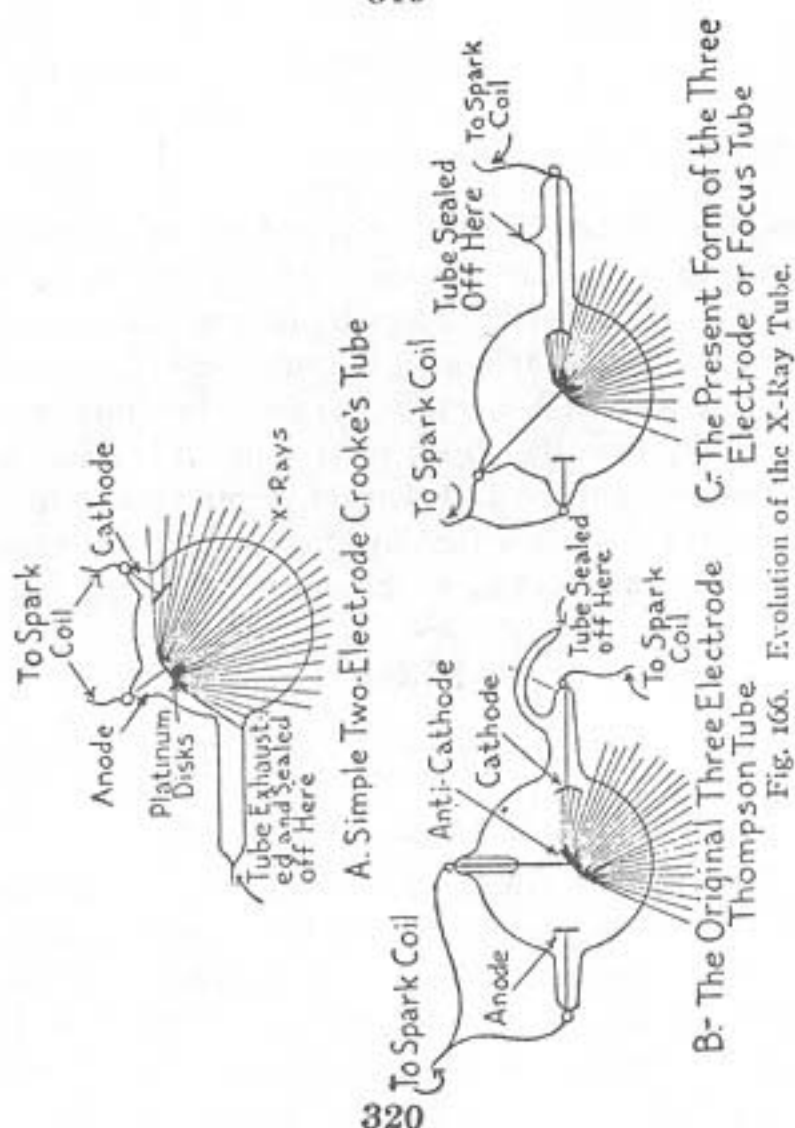


Fig. 166. Evolution of the X-Ray Tube.

more nearly in one direction, and this resulted in the three-electrode tube. Prof. Elihu Thompson was the first to design a three-electrode tube, which is shown at B.

This tube consisted of a third electrode formed of a disk of platinum set between a disk anode and a concave cathode. The third electrode, or anti-cathode, as it is called, set at an angle of 45 degrees, and the X-rays, which have their origin on this, are thrown down, as shown at B. This type of tube is now called a single focus tube, and the commercial form of it is shown at C.

How a Crookes Tube Generates X-Rays.—In a Geissler tube the air is only partly pumped out, so that the vacuum is very low. Under this condition

when the tube is energized by an induction coil or other source of high voltage electricity, instead of sparks jumping across from one electrode to the other, as they do in air at ordinary pressures, the whole tube becomes filled with a vapor-like light. This action is due to the molecules of air which are still in the tube, and which are forced from one electrode to the other; in this line of travel they strike each other with such force that the *electrons*¹ of which the molecules are formed are set into rapid vibration.

¹ Molecules are made up of atoms; each of these, in turn, is made up of a central core of positive particles of electricity, and these are surrounded by negative particles of electricity, which are called *electrons*.

In a *Crookes tube*, so called because Sir William Crookes first made it, it is expanded in a bulb-like shape, and the air is pumped out of it so perfectly that a high vacuum is formed. Now, when a high voltage

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current is sent through it, it takes on new properties and behaves in an entirely different way. The vapor-like light does not appear, but, instead, the interior of the tube remains perfectly clear, and the glass of which the tube is made becomes brilliantly fluorescent; this is caused by the bombardment of the few molecules of air that still remain in it against the surface of the glass.

How an X-Ray Outfit is Connected Up.—The battery, or other source of current, is connected with the binding posts of the primary coil of a spark coil in the usual way, and the terminals of the secondary coil of the spark coil are connected with the anode and

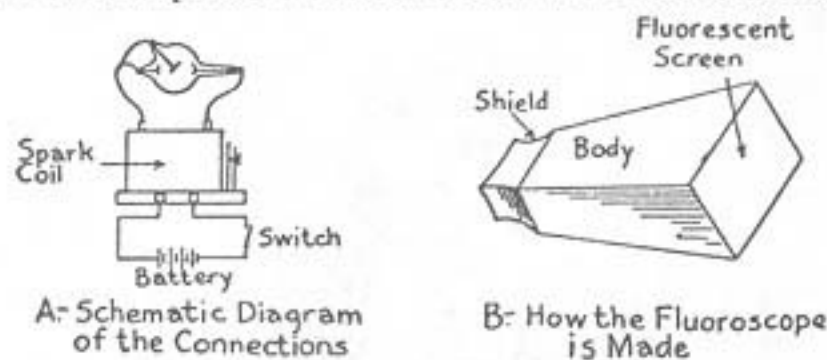


Fig. 167. An X-Ray Outfit.

cathode of the X-ray tube, while the anti-cathode, that is, the middle electrode which sets up the X-rays, is connected with the anode, and all of which is shown at A in Fig. 167.

The Fluoroscope and How it is Made.—The word *fluorescent* means that property which some transparent bodies have of changing the length of light waves and, hence, of changing their natural color

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to some other color, as when green crystals of fluor spar

throw off a blue light. Now, just as light waves when they act on certain substances cause them to become fluorescent, so also do the X-rays, and, indeed, it was this action which led, as you have seen in the beginning of this chapter, to the discovery of the X-rays by Roentgen.

There are a number of chemical salts that become fluorescent when the X-rays are directed upon them, but the two chief ones are platino-cyanide of barium and tungstate of calcium. To make a fluorescent screen, it is only necessary to glue, or otherwise cement, one or the other of these salts to a sheet of cardboard.

Since it is desirable to shut out all of the outside light when observing the action of the X-rays on the fluorescent screen, just as it is when you are looking through a stereoscope, Mr. Edison got up the simple device known as the *fluoroscope*. It consists of an opaque, pyramidal shaped box having at its large end the fluorescent screen and with the salt covered side of it facing the inside; at the small end is a shield like that of a stereoscope, and, also like the latter, its edge is covered with a soft, fluffy fabric, so that all of the outside light will be excluded when you hold the fluoroscope to your eyes. It is shown at *B*.

When you hold your hand on the outside surface of the screen of the fluoroscope with the X-ray tube in action before it, as shown in *Fig. 168*, the rays of the latter will pass through the flesh of your hand and cause the salts of barium or calcium to fluoresce, and then your eye will see the light of it; at the same time

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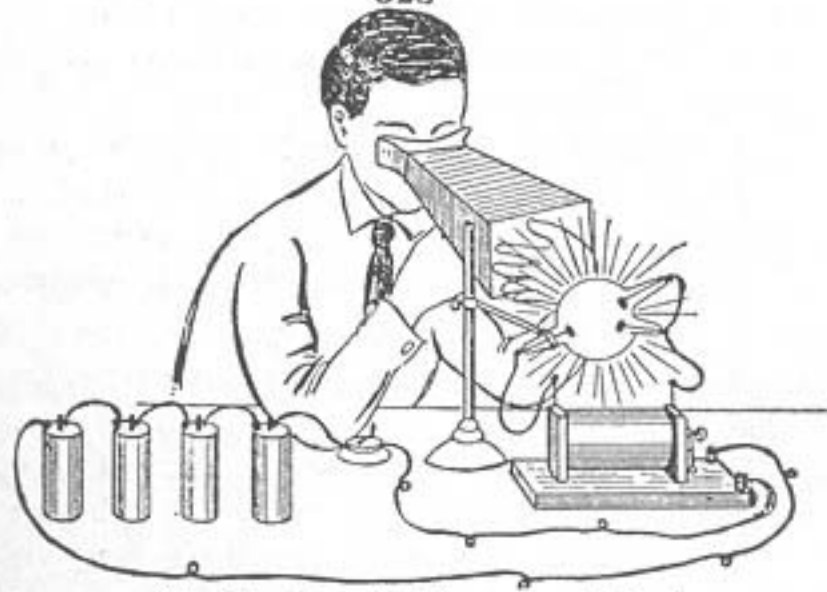


Fig. 168. How the Fluoroscope is Used.

the bones of your hand stop the X-rays, and that part of the fluorescent screen immediately under them remains dark, so that you will see the shadow of them.

The Photographic Plate and How it is Used.—

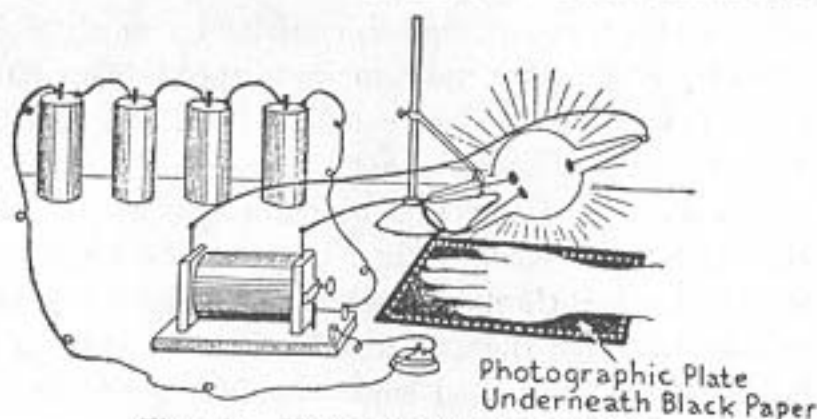


Fig. 169. How a Radiograph is Made.

The X-rays act on a photographic plate exactly as light waves do, and, hence, if you enclose a plate in a light-tight holder, place your wide open hand flat on

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top of it, as shown in *Fig. 169*, and set the tube in action, you will obtain a picture of the shadow of the bones of your hand. Since a shadow picture of an object, or *radiograph*, as it is usually called, can only be made with an X-ray tube, it cannot be either larger or smaller than the object from which it is made, but neither this nor the fact that the pictures so made are really of the shadow the object casts limits the use of the X-rays as much as might naturally be supposed.

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XIX

WIRELESS TELEGRAPHY AND TELEPHONY

THE WIRELESS TELEGRAPH

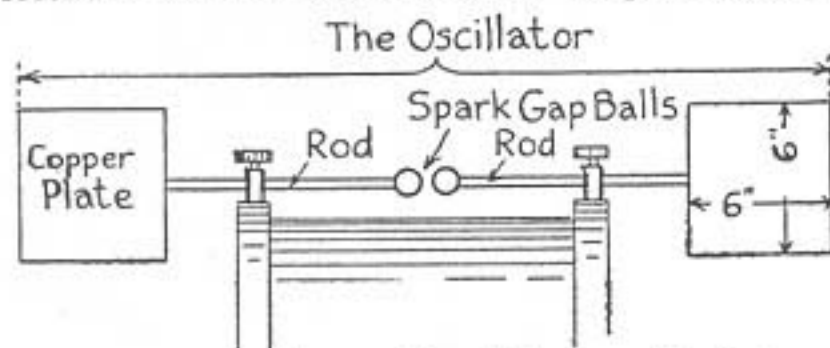
THE wireless telegraph was invented by William Marconi at Bologna, Italy, in 1896, and in his first experiments he sent dot and dash signals to a distance of two hundred or three hundred feet. The first vital experiments that led up to the invention of the wireless telegraph were made by Heinrich Hertz, of Germany, in 1888, when he showed that the spark of an induction coil set up *electric oscillations* in an *open circuit*, that is, a wire whose ends are not connected together, and that the energy of these oscillating currents was, in turn, sent out in the form of electric waves. He also showed how they could be received at a distance and without the aid of connecting wires, by means of a *ring detector*, which he called a *resonator*.

Hertz's Classic Experiments.—To set up the oscillations and to radiate the energy of them in the form of electric waves, Hertz used a very simple apparatus, which he called an *oscillator*, and you can do the same. Cut out two sheets of zinc or copper six inches on the sides and solder them to the free ends of

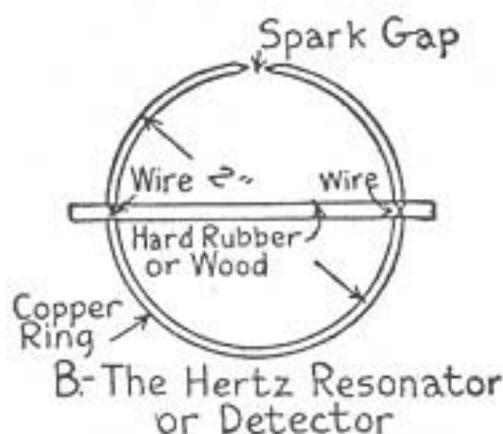
the spark-gap rods; now slip the rods through the binding posts of your spark coil and then put the balls on the opposed pointed ends of the rods, as shown at A in Fig. 170.

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To make the *detector*, take a piece of soft copper wire one-eighth inch in diameter and two feet long, and file down each end to a sharp point; bend it into a ring and have the points come within one-thirty-second of an inch of each other. If possible, get a



A- The Hertz Oscillator, or Radiator



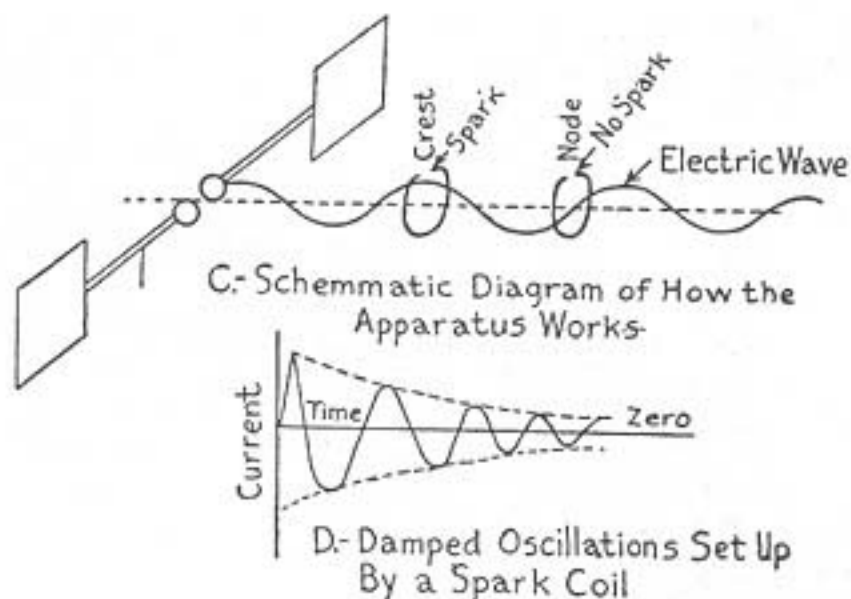
(A-B) Fig. 170. The Hertz Apparatus.

strip of hard rubber, or, if this is not at hand, use a strip of hard wood about three-sixteenths of an inch thick, one-half inch wide and twelve inches long, and fasten the ring to it with some wire, as shown at B. The purpose of this is to insulate it from your hands when you are holding it, and it also permits a better adjustment of the points.

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How to Make the Experiment.—Now for the classic experiment. Set your spark coil into action and hold the ring detector within a few feet of and directly in a line with the spark of the coil, when sparks will jump across the gap of the ring detector. Now move slowly away from the coil, and you will find that at certain distances the spark in the ring detector gets very bright and at others it gets very weak. This shows that the energy from the oscillator is in the form of waves, the bright sparks indicating the crests of the waves and the weak sparks indicating the nodes of the waves, as shown at C.

Theory of the Hertz Experiment.—The action



(C-D) Fig. 170. The Hertz Apparatus.

that takes place in the spark coil and oscillator is this: When the vibrator makes or breaks the current, one of the plates and the spark-gap rod connected with it is charged with +, or *positive* electricity, and the other

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one is charged with —, or *negative* electricity. When these are fully charged, they strain the air, which separates the spark-gap balls until it breaks down, when the two charges rush together to equalize the difference of pressure.

As these charges rush together they burn up the air in the gap, and this is what makes the spark; the surrounding air then rushes in to fill up the vacuum, and it is this that causes the crackling sound. When the spark passes, the charges of electricity form a current, and this surges from one of the metal plates through the spark, which acts as a conductor, to the other plate and back again three or four times, as shown by the curve at D, and this is called an *oscillating current*, or *electric oscillation*.

Since the *inductance* and *capacitance* of the plates and rods are very small, the frequency with which the current oscillates may be at a rate as high as 100,000,000 times per second, and this will give a wave length of three meters, or, roughly, nine feet. But you must not get the idea that this many oscillations actually take place every second because after the current is set up it is damped out by its energy being radiated as waves, the resistance of the spark gap, etc. Further, between each set of oscillations a comparatively long time elapses while the oscillation system is being charged by the secondary coil before a high enough pressure, or potential, is reached again to break down the air of the gap and set up another spark.

What Electric Waves Are.—As the current

surges, or oscillates, to and fro between the plates, it sets up a correspondingly rapid alternating magnetic field around and at right angles to it, in what is called the *ether*. The ether is a substance that is a million times thinner than air, as air is thinner than water, and it fills all space.

The rapidly alternating magnetic field produced by the oscillating current sets up an alternating electric field, and this, in turn, a magnetic field, and so on, and these strains in the ether as they extend on out in space are called *electro-magnetic waves*, or, as Hertz called them, electric waves, while they are now generally called just *waves* for short. These waves travel out from the oscillator at exactly the same speed as light waves travel, that is, 186,500 miles per second, and they keep on going, just like light waves, until their energy is used up by the resistances they meet.

When the electric waves strike the ring detector their energy is changed into high frequency electric currents, or oscillations, and as these surge in the ring circuit they set up sparks exactly like those of the oscillator system, but of course they are much more feeble. This, then, is the fundamental principle involved in (1) setting up oscillations which send out (2) electric waves, and these in turn (3) set up oscillations in the ring detector. These operations form the bases of wireless telegraphy as it is practiced to-day by the spark method.

The Invention of the Coherer.—In 1890 Edouard Branly, of France, showed that metal filings in a tube were drawn to each other, or *cohered*, as it is called, when electric oscillations flowed through them, and this device he termed a *radio conductor*; later this was improved upon by Sir Oliver Lodge, who called it a

coherer, by which name it has been known ever since. The coherer is wonderfully sensitive to the action of electric oscillations flowing through, as against the Hertz ring detector, and it was used by Marconi in his first experiments with the wireless telegraph and for a long time thereafter.

How to Make a Simple Coherer Indicator.—To make a simple and sensitive device for detecting the presence of electric waves sent out by the Hertz oscillator described above, mount two large double connector binding posts one inch apart on a wood base about eight inches wide and ten or twelve inches long, as shown in *Fig. 171*. Now cut off two pieces of one-eighth inch thick brass rod twelve inches long, and

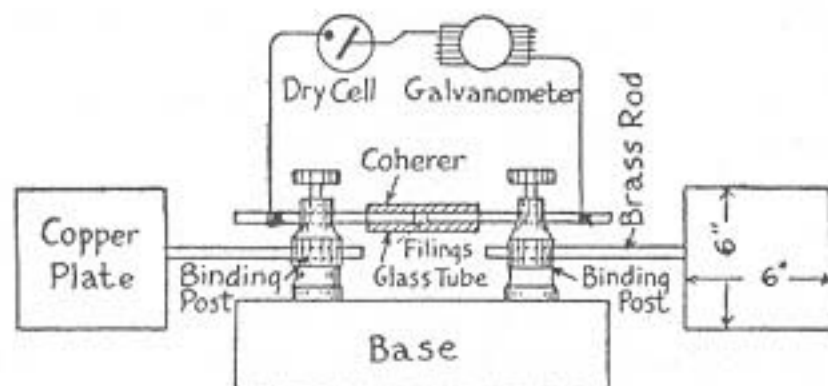


Fig. 171. Schematic Diagram of a Simple Coherer Indicator.

This done, cut off two pieces of three-thirty-seconds of an inch brass rod two inches long, and file one end of each one off perfectly flat and even; fit these two plugs, as they are called, into a glass tube one inch long, so that they will be snug and yet slide easily. Now take the rods out of the tube and slip them

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through the holes in the smaller binding posts. This done, file off a bit of coin nickel and coin silver, and put a pinch of the filings thus obtained in the tube. Finally, hold the tube between the binding posts and push the brass plugs into it until the filings are pressed together, as is also shown in *Fig. 171*.

Now slip the free ends of the brass rods that are secured to the sheets of zinc or copper into the lower holes of the binding posts, and then connect one of the coherer plugs with one post of a dry cell, and the other post of the latter to one of the terminals of a galvanometer,¹ and the other terminal of it with the remaining plug of the coherer.

¹ An explanation of how to make it will be found in Chapter V.

Before you can receive the indications of the electric waves sent out, you must adjust the coherer, and this you do by screwing up one of the plugs tight in the binding post; now grip the other plug with your finger, and with a twisting motion push it against the filings in the tube until the needle of the galvanometer swings over. When this happens it shows that the resistance of the filings has dropped enough to let the current from the dry cell flow through the coherer; tap the filings with a pencil to *decohere* them, when the needle will swing back again.

How to Use the Indicator.—Set the indicating device, say, ten feet away from, but in a line with, the sender, so that their metal plates will be parallel with each other, and then make a spark pass between the balls of the spark gap of the sending apparatus.

The moment the spark takes place, the needle of the

galvanometer will swing over, which shows that electric oscillations are surging in the system formed by the plates, the rods and the coherer, that these currents have cohered the filings and hence greatly lowered the resistance of the coherer; this action allows the current from the dry cell to flow through the galvanometer, when the needle will swing over. Before it will swing back you must stop the coil from sparking and tap the tube with a pencil; this will break the filings apart, so that the coherer will be restored to its normally high resistance, when the current from the dry cell can no longer flow through them.

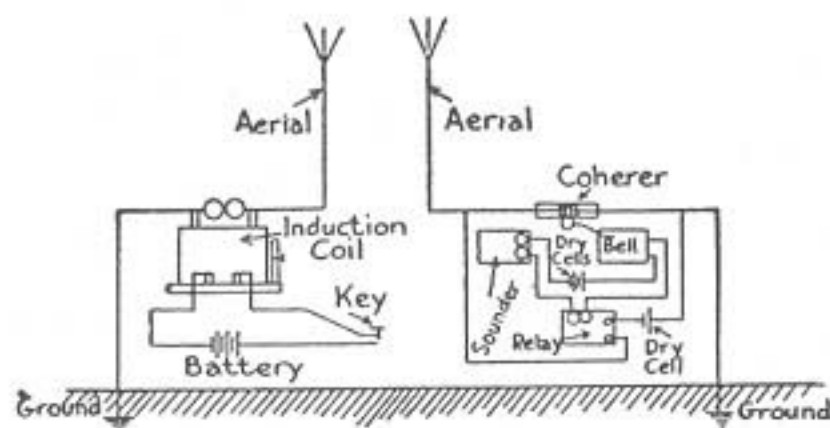
The Invention of the Wireless Telegraph.—Alexander Popoff, of Russia, was the first to construct a real wireless receiving set, which he did in 1895, but this he used to receive indications of distant thunder storms. His receiver consisted of a coherer, one plug of which led to a rod that reached into the air, and the other side to a plate which was buried in the earth. The coherer was connected with a battery, and instead of a galvanometer to indicate the incoming trains of electric waves, it had an electric bell which rang out the indications. The bell was so placed that when it rang, the hammer would strike the coherer tube and so decohere the filings automatically.

William Marconi was the first to connect an aerial wire to one side of a spark gap and a ground to the other side. He used a spark coil to energize this oscillation system, and employed a telegraph key to break up the primary current into the alphabetic Morse code. This formed his sending apparatus.

For his receiving apparatus he used Popoff's scheme, but vastly improved it, and this included a vacuum

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coherer, that is, one with the air pumped out, a tapper to tap back the filings, connected a sensitive polarized



A: First Marconi Wireless Telegraph Transmitter

B: First Marconi Wireless Telegraph Receiver

Fig. 172. The First Marconi Wireless Telegraph Set.

relay with the coherer, and added a Morse register which printed the received dots and dashes on a paper tape. This apparatus was in use for several years until the coherer was supplanted by the crystal detector, and the cumbersome Morse register by a pair of head telephone receivers.

How to Make a Simple Wireless Telegraph Set.—A wireless telegraph system consists of two parts, and these are (1) the *transmitter* or *sender*, and (2) the *receiver*, or more properly, the *receptor*. All you need to do to make an *open circuit transmitter*, as the first kind of Marconi sender is called, is to connect one of the spark-gap rods with a vertical wire *twenty* or more feet high; this must be held in the air by an insulator secured to a mast or other support. Then connect the other spark-gap rod with a plate buried in the earth, as shown at A in Fig. 172.

For a receiver you can use the same kind of a coherer described above, but mount it on a wood base *two* by *three* inches on the sides. Then buy a *75 ohm pony relay*, a good *electric bell* and a *telegraph sounder*. The relay has four binding posts, two of which are connected with the terminals of the magnet coils; one of the other two posts is connected with a fixed contact point, and the other with a movable contact point, which is secured to a delicately pivoted armature, and this is worked by the magnet. The bell is used only as a tapper to tap back the filings of the coherer, and you should therefore take off the gong. The sounder is used to click off the dots and dashes, as in the regular wire telegraph set described in Chapter VII.

How to Connect Up the Apparatus.—Connect up one of the plugs with a water or gas pipe or a zinc or copper plate buried in the ground deep enough to make contact with the moist soil, and connect the other plug with the aerial wire that is held in the air by an insulator, which, in turn, is secured to a mast or other support, as in the case of the receiver described above.

This done, connect one of the plugs of the coherer with one of the posts of the magnet coil of the relay; connect the other plug of the coherer with one of the posts of a dry cell, and connect the other post of the latter with the other post of the magnet coil of the relay. Now connect the binding post of the fixed contact point of the relay with one of the poles of a bat-

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ttery of two or three dry cells, and the other post of the latter with one of the posts of the sounder and one

of the posts of the tapper. Finally, connect the post of the movable contact point of the relay with the other post of the sounder and the other post of the tapper, that is to say, connect the tapper and sounder in parallel with the battery and the contact points, and all of which is shown in the wiring diagram in *Fig. 172*.

How to Adjust the Receiver.—After you have adjusted the coherer, as described above, screw and unscrew the adjusting spring of the armature relay until the current that flows through the coherer and the relay is just enough so that the filings of the former will cohere when, of course, the current flows through the coils of the latter and the armature is drawn to the poles of them; this brings the points into contact, which closes the second circuit and makes the hammer of the bell tap the coherer tube, when its normal high resistance is once more brought about.

Now, every time you press the key of the transmitter the electric waves that are emitted by the sending aerial will impinge upon the receiving aerial, when their energy is converted into electric oscillations; as these surge forth and back through the coherer from the aerial to the ground, they cohere the filings and so operate the tapper and the sounder.

A wireless telegraph set of this kind will operate to a distance of a mile or more, but the Government will not permit you to use it, as it sends out too broad a wave, and, hence, it interferes very greatly with the other receivers in the vicinity.

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THE WIRELESS TELEPHONE

The wireless telephone was invented by the author of this book at Narberth, Penn., in 1899, and in his first experiments the human voice was transmitted to a distance of three blocks. Different from the wireless telegraph, the wireless telephone cannot be operated by the damped and periodic oscillations set up by a spark, but it can only be worked by sustained oscillations of constant amplitude, and in the early days the only known way to produce these was by means of an electric arc light, and this had to be energized by a direct current of 500 volts. That a direct current arc light transforms a part of its energy into electric oscillations was shown by Firth and Rogers, of England, in 1893.

The present author was the first to connect an arc lamp with an aerial and a ground and to use a microphone transmitter to modulate the sustained oscilla-

tions thus set up. The receiving apparatus consisted of a variable contact known as a *pill box detector*, which Sir Oliver Lodge had devised, and this was connected with an Ericsson telephone receiver, then the most sensitive made. A later improvement (1908) for setting up sustained oscillations was the author's *rotating oscillation arc*. Since those early experiments wonderful advances have been made in the art of wireless telephony and the end is not yet in sight.

How to Make a Simple Wireless Telephone Transmitter.—To make this simple, experimental telephone transmitting set, you need: (1) a vacuum tube which will set up the sustained oscillations, as shown at *A* in *Fig. 173*; (2) a tuning coil, as shown at

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B; (3) an aerial condenser; (4) a grid and blocking condenser; (5) a grid leak; (6) a six-volt storage battery; (7) a fifty-volt dry cell battery; (8) an oscillation choke coil, as shown at *C*; and (9) a microphone transmitter, as shown at *D*.

The most sensitive *detector* of electric waves at the present time is the vacuum tube and it is not only a detector of electric waves, but it *amplifies* the oscilla-

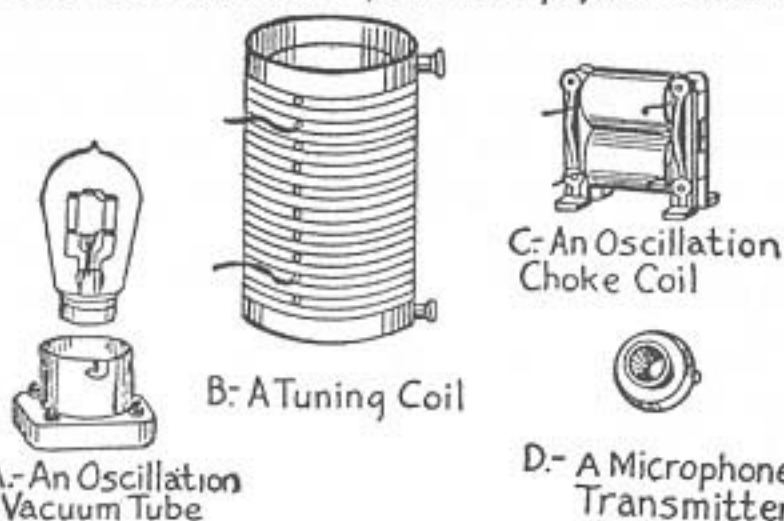


Fig. 173. Apparatus for a Wireless Telephone Transmitter.

tions they set up as well, and, finally, it sets up sustained oscillations, as shown by the curve at *A* in *Fig. 174*. A vacuum tube in its simplest form consists of a glass bulb like an incandescent lamp, in which a wire filament and a metal plate are sealed; the air is then pumped out of the tube so that the filament cannot burn. The three-electrode vacuum tube is much more sensitive than the two-electrode tube, and it is in consequence the kind that is now used. It has a third electrode, or *grid*, as it is called, and this is placed between the wire filament and the metal plate, as shown at *B*.

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The tuning coil is formed of a cylinder of wood or other insulating material, around which is wrapped

about twenty-five turns of insulated copper wire. The aerial condenser has a capacitance of .002 microfarad, and the grid and blocking condensers each have a capacitance of .001 microfarad. The grid leak is

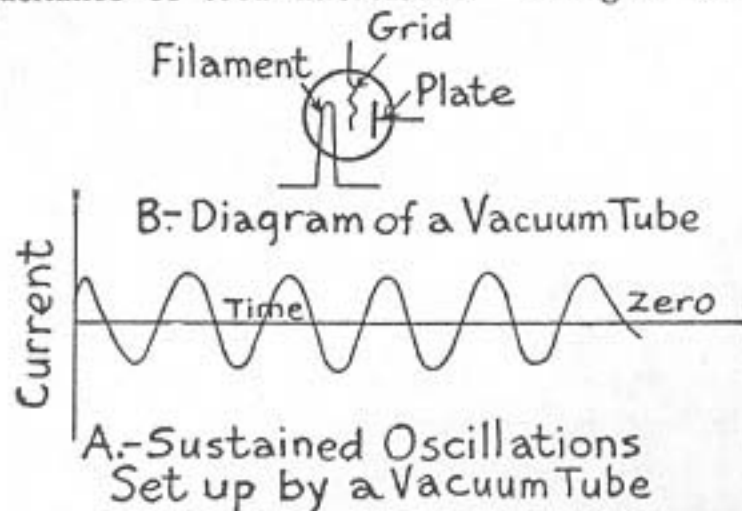


Fig. 174. The Vacuum Tube and the Oscillations It Sets Up. simply a resistance of about 5,000 ohms. The six-volt storage battery is used to heat the filament of the vacuum tube, and the fifty-volt dry cell battery supplies the current, which is changed by the vacuum tube into sustained oscillations. The choke coil is a little coil of about 100 turns of No. 28 double-cotton-covered wire wound on a cardboard tube two inches in diameter, and it is placed between the + or positive wire leading from the dry cell battery to the plate of the vacuum tube and the tuning coil to prevent the oscillations from surging back through the battery. Finally, the microphone transmitter is a regular telephone trans-

mitter.

How to Connect Up the Apparatus.—The way the various pieces of apparatus are connected together

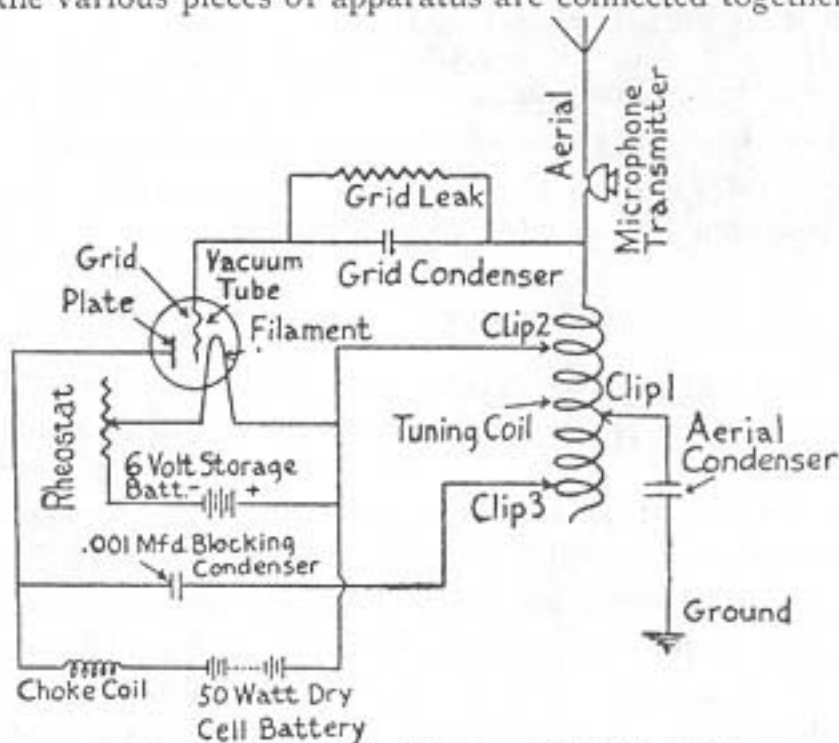


Fig. 175. A Simple Vacuum Tube Wireless Telephone Transmitter.

is shown in the wiring diagram, Fig. 175. Begin by connecting the lower end of the aerial wire with one of the terminals of the microphone transmitter, and the other terminal of this to one end of the tuning coil. Now connect clip 1 of the tuning coil to one end of the aerial condenser, and the other end of the latter with the water pipe or other ground.

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Next connect one end of the grid condenser to the post of the tuning coil that makes connection with the microphone, and the other end to the grid of the tube, and then shunt the grid leak around the condenser. Connect the + or positive electrode of the storage battery with one terminal of the filament of the vacuum tube, the other terminal of the filament with one post of the rheostat, and the other post of this with the — or negative electrode of the storage battery.

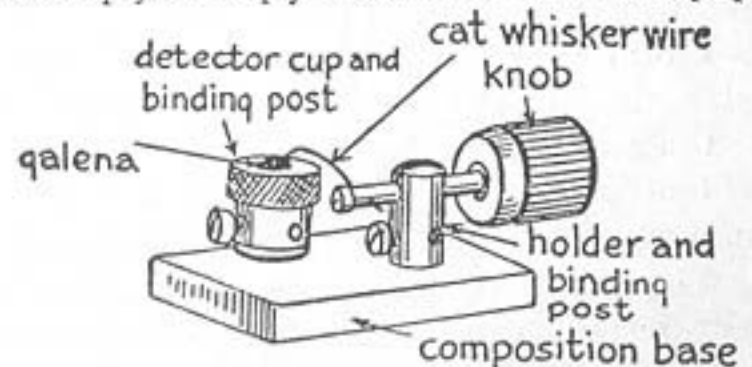
This done, connect clip 2 of the tuning coil to the + or positive electrode of the battery, and then bring a lead from it to the — or negative pole of the dry battery. Now connect clip 3 of the tuning coil with one end of the blocking condenser, the other end of this with one terminal of the choke coil, and the other terminal of the latter with the carbon pole of the dry battery, when your wireless telephone transmitter is complete, and with it you can send to a distance of a mile or more.¹

How to Make a Cheap Wireless Telephone Receiving Set.—You can make a crystal receiving set with which you can receive either wireless telegraph or telephone messages for five dollars or less. All you need for this set is (1) a crystal detector; (2) a tuning coil; and (3) an earphone.

The crystal detector consists of an insulating base, and on it is mounted a brass support, through which a rod slides; on one end of this there is fixed a hard rubber adjusting knob, while the other end carries a thin piece of phosphor-bronze wire, called a cat-

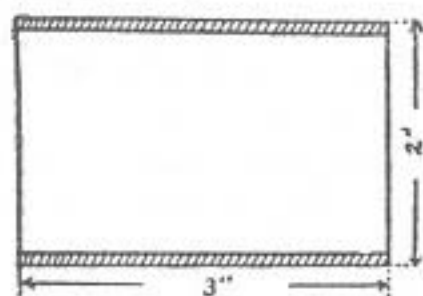
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whisker. To fix the crystal, which is a piece of galena, in the cup you simply unscrew the knurled cap, place



A. Baby Crystal Detector.

(A) Fig. 176. Apparatus for a Cheap Receiving Set.



A. cross section of paste board tube



B. the 7 point switch

B. How the Tuning Coil is Made.

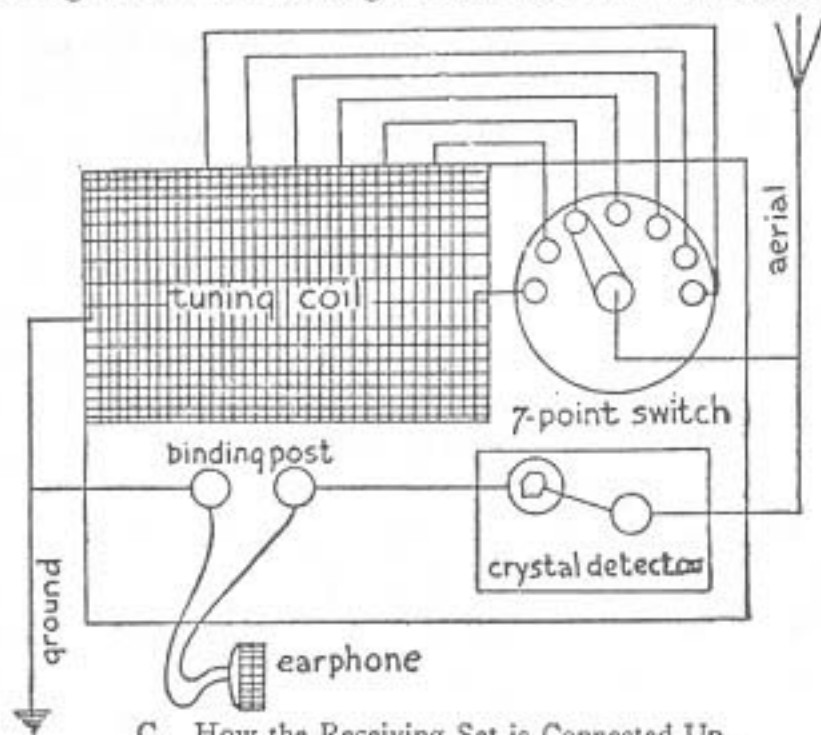
(B) Fig. 176. Apparatus for a Cheap Receiving Set.

the crystal in the little well and screw the cap back on again. The free end of the cat-whisker wire is then adjusted so that it will rest lightly on the exposed part of the crystal, as shown at A in Fig. 176.

To make the tuning coil, wind 250 turns of No. 36 copper enamelled wire on a cardboard tube two inches in diameter. As you wind on the wire take a tap off

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at every fifteen turns, that is, scrape the wire and solder on a piece seven or eight inches long, as shown at C. Bring these wires through to the inside of the tube and



C. How the Receiving Set is Connected Up.



D. Head Set (1000 Ohms).

(C-D) Fig. 176. Apparatus for a Cheap Receiving Set.

do this until you have taken off six taps, and then bring them out through the open end. Now buy a round wood-base with seven contact points on it, as shown at B.

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Finally, buy a head-phone that is wound to not less than 500 ohms resistance, and preferably to 1,000 ohms resistance. This will cost \$1.75 with a cord, and for \$1.00 extra you can get a head-band for it, and then your phone will look like the one shown at D.

How to Connect Up the Parts.—Mount the coil on a wood base one-half inch thick, three and one-half inches wide, and five and one-half inches long; then connect one end of the coil to one of the end points on the switch, and connect each succeeding tap to one of the switch points. This done, screw the switch down to the base; finally, screw the detector to the base and screw two binding posts in front of the coil, for the earphone.

Connect up all of the parts, as shown in the wiring diagram in Fig. 177. If you have no aerial, try con-

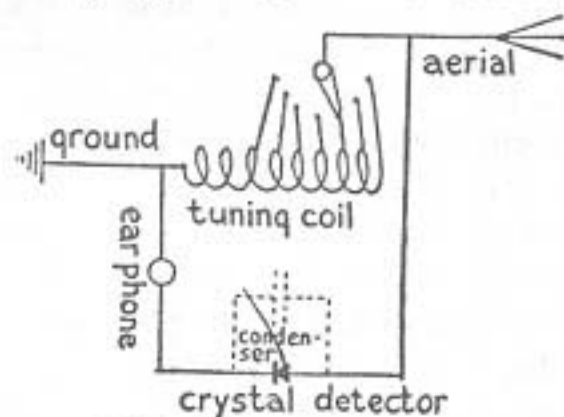


Fig. 177. Wiring-Diagram of the Receiving Set.

necting the receiver up to a rain pipe that is not grounded, to an iron or brass bed, or to the steel frame of an umbrella. For a ground you can use a water pipe, or an iron pipe driven into the ground. Put on

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your head-phone, adjust the detector, and move the lever over the switch contacts until it is in adjustment and then, if all of your connections are properly made, you should be able to pick up messages.

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APPARATUS FOR AND EXPERIMENTS WITH HIGH FREQUENCY CURRENTS

THE most spectacular experiments in the whole realm of electricity can be performed with *high frequency currents*, and while they have no appreciable effect on the human body as far as the sensory nerves are concerned, they produce remarkable dynamic phenomena, such as melting a wire held in the hand, obtaining a brush discharge from the finger-tips, light-

ing an incandescent lamp with a single wire and without any wires, and many other equally striking effects.

What High Frequency Currents Are.—The word *cycle* is used to mean two complete reversals of an alternating current, and the word *frequency* is used to mean the number of cycles an alternating current makes per second. When an alternating current makes less than 10,000 cycles per second, it is called a low frequency current, and when it makes more than 10,000 cycles, it is called a high frequency current. When the frequency is greater than 100,000 cycles per second, the currents are called *electric oscillations*, or just *oscillations* for short. In wireless telegraph and telephone sets oscillations having frequencies of from 150,000 to 6,000,000 are used, while frequencies as high as 10,000,000 up to 100,000,000 are often used in high frequency work.

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How High Frequency Currents Are Set Up.—When the primary coil of a spark coil (See Chapter XVI) is energized by a battery or other source of current and the spark-gap electrodes are kept far enough apart so that the spark cannot pass between them, the alternating current set up in the secondary coil will have a frequency which is exactly the same as that of the frequency of the vibrator which makes and breaks the primary current. The currents set up by and in the secondary coil are of *high potential*, which means high voltage, but their frequency is very low.

If now the terminals of the secondary coil are brought close enough together so that their potential difference will break down the air between them, then a spark will pass and the positive and negative charges will rush together; when this action takes place a current is set up which will surge forth and back through the *oscillator*, as Hertz called the open circuit formed by the spark gap and the spark-gap electrodes, at the rate of hundreds of thousands of times per second, depending on the inductance and capacitance of it, which in this case is very small indeed.

Now, curiously enough, low potential and low frequency currents produce strong physiological effects, while high potential and high frequency currents do not. The result is that if you place your finger on one or the other of the binding posts of the spark coil you will get a shock; this is because your body has capacitance, that is, it acts as a capacity, and you get the full force of the low frequency current that is set up by the vibrator of the coil. To convert all of the energy of the low frequency currents into high frequency

currents and get more current strength (amperage) into them, additional apparatus must be used in connection with your spark coil.

Kinds of High Frequency Apparatus.—There are two distinct kinds of apparatus used for setting up high frequency currents for the production of high frequency phenomena, and these are (1) the *unipolar type*, that is, where one terminal, or electrode, of the high frequency coil gives off practically all of the discharge; and (2) the *bipolar type*, where the high frequency discharge takes place equally between the terminals, or electrodes, of the high frequency coil, just as it does between the spark-gap electrodes of a spark coil.

In high frequency coils of whatever kind, or make, the high frequency currents are set up by the discharge of a condenser through a helix of wire, and it is the capacitance of the former and the inductance of the latter that determines the frequency of the currents. The unipolar type of apparatus is known as the *D'Arsonval coil*, while the bipolar apparatus is known as the *Tesla coil*, after the men who first devised and used them. The unipolar type is largely used for the treatment of diseases, and the bipolar type for experiments in general, but either type of coil can be used for any purpose where a high frequency current is necessary.

In the D'Arsonval type of high frequency apparatus only one coil of wire is used, but the connections are so made that it is the equivalent of a primary and secondary coil. In the Tesla type of high frequency apparatus two coils are used, and these are separate

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and distinct from each other, just as the primary and secondary coils are of a spark coil.

How to Make a Unipolar High Frequency Coil.—A unipolar, or D'Arsonval, high frequency apparatus consists of (1) a spark coil, fitted with (2) a spark gap, (3) two *one* pint Leyden jars, or other condensers of small capacities, and (4) a single layer coil of No. 14 or 16 insulated copper wire wound on a thoroughly seasoned wood drum or a heavy pasteboard tube, either of which you can easily make. Whichever kind of drum you use, give it several coats of shellac varnish.

A wiring diagram of the connections is shown in *Fig. 178*, and from this you will see that each side of the spark gap of your spark coil is connected with the outside coating of a small Leyden jar; the inside coating of one of the jars is connected with the lower end

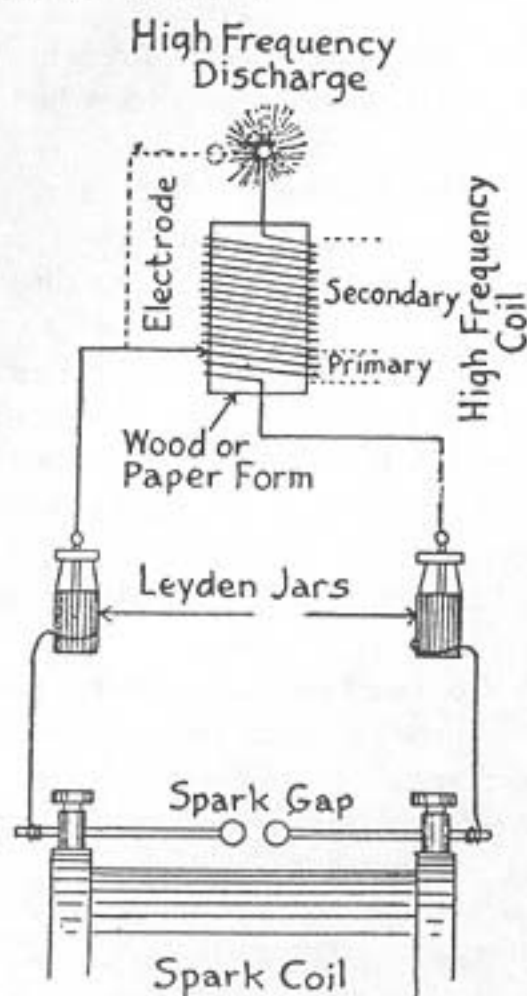


Fig. 178. Schematic Diagram of a D'Arsonnal Unipolar High Frequency Apparatus.

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of the coil of wire, while the inside coating of the other jar is connected to the coil at the third turn from the bottom. This part of the coil serves as the primary and the turns above it as the secondary, and the potential is stepped up by the oscillating magnetic field just as though the two coils were separated from each other.

If you can make a high frequency coil with a sliding contact—a large single coil wireless tuner will serve admirably—you can get much better results, for then you can tune the Leyden jar circuit to the upper part of the coil, and so get the greatest resonance effects, when the high frequency currents emitted by the free terminal electrode will be very strong. Should you want to set up high frequency sparks, connect a wire to the lower end of the coil and bring it up to and near the free electrode of the coil, as shown by the broken line in the diagram.

How to Make a Bipolar High Frequency Coil.—A bipolar, or Tesla, high frequency apparatus consists of: (1) a spark coil, with (2) a spark gap, (3) two one pint Leyden jars, or other high potential condensers, and (4) a high frequency coil, which is formed of a primary and a secondary coil that are

widely separated from each other. Different from a spark coil, there is no iron core in a Tesla high frequency coil, and, hence, the primary coil is placed outside of the secondary, as shown in Fig. 179. This ar-

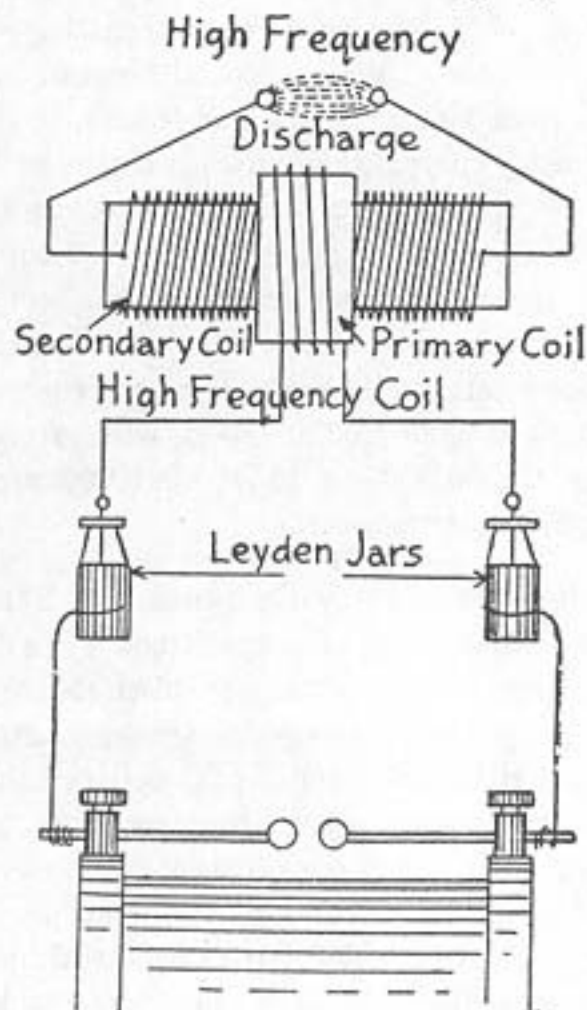


Fig. 179. Schematic Diagram of a Tesla Bipolar High Frequency Apparatus.

range is made possible because high frequency currents set up a powerful magnetic field, and, consequently, an iron core is not necessary. As the strongest part of a magnetic field is inside of a coil,

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the primary coil is placed outside of and over the secondary coil.

To make the primary coil, get a well seasoned wood tube, or a pasteboard tube, three inches high and eight inches in diameter, and wind three or four turns of No. 10 or 12 insulated copper wire around it. The best kind of wire to use for the primary is flexible lamp cord, as this is formed of stranded wire; get a five foot length of it and untwist the two cords, straighten them, and scrape the insulation from both ends of each piece. Now twist the end of one length of the cord to one end of the other piece, and solder the joints so made separately. This done, wrap some friction tape, as the electricians call it, around the joint and then wind it on the cylinder so that each turn will be separated from the next turn to it by about one-quarter inch.

To make the secondary coil, get a pasteboard tube six inches in diameter and twelve inches long, and give it two or three coats of shellac varnish. This done, wind it full of No. 18 or 20 double-cotton-covered magnet wire, which you have further insulated by drawing it through a melted compound made of resin and beeswax in the proportion of one part of the former to three parts of the latter. Or better yet, wind it with a stranded wire that is sold under the trade name of litzendraht.

Having made the coils, the next and last thing to do is to mount them on a base. To do this, slip the secondary coil inside of the primary coil and secure them to a board, so that the secondary coil is exactly in the center of the primary coil, and they are insulated from each other as well as from the base.

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A schematic wiring diagram of a complete Tesla bipolar high frequency apparatus is shown in *Fig. 179*, and a glance at this will show you that it is connected up in exactly the same way as the D'Arsonval unipolar apparatus to the high frequency coil itself. The inside coatings of the Leyden jars are connected to the end wires of the primary of the Tesla coil, while the ends of the wires of the secondary form two active electrodes.

How to Use a Power Transformer.—Where you have an alternating current only that is available as the initial source of power, then you can use a *power transformer* to energize the high frequency coils, instead of a spark coil. A one-quarter kilowatt transformer is large enough for energizing the high frequency coils described above. Where a power transformer is used to energize the high frequency coil, the Leyden jar or other condenser is connected across the terminals of the secondary coil of the power transformer.

Some Experiments With High Frequency Currents.—I shall not try to go into detail concerning the experiments you can do with your high frequency apparatus, but, instead, I shall give you an outline of a number of them, which with the accompanying pictures, will enable you to perform them successfully. The experiments that have to do with light can be performed to the best advantage in a dark room. All of the experiments, and many more, can be performed

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without the slightest danger, as the frequency is so high the current is absolutely harmless.

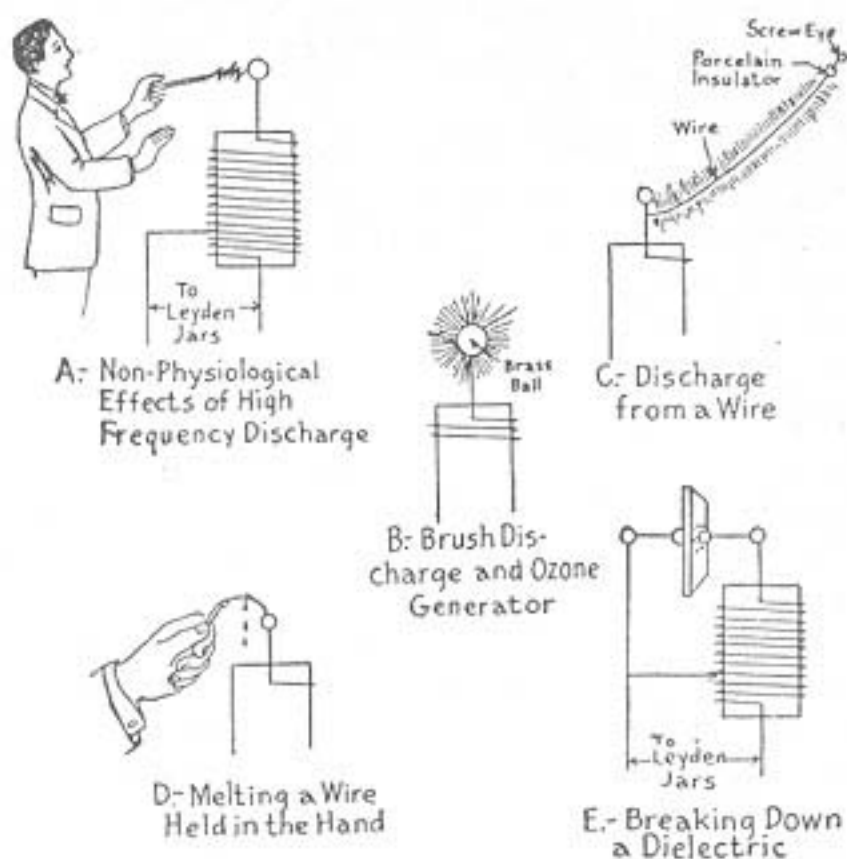
(1) Let the discharge from the terminal of the high

frequency coil strike your hand and you will feel a slight pricking sensation on the spot where the discharge comes in contact with the flesh. (2) Hold an iron rod, or other piece of metal, tightly in your hand and let the discharge strike the latter, as shown at *A* in *Fig. 180*, when you will not be able to feel the high frequency current at all.

(3) Hold a Geissler tube in your hand near the discharge electrode, but far enough away so that the sparks will not pass, when the tube will light up. (4) Do the same thing with an ordinary incandescent lamp, or better, connect it to the discharge electrode with a single wire, when it will glow with a green *fluorescent* light. (5) Place a piece of *willimite*, which is a mineral, so that the discharge will strike it, when it will glow with a greenish light. (6) Many other minerals and precious stones will likewise be rendered fluorescent under the action of the high frequency discharge.

(7) Connect a brass ball a couple of inches in diameter to the discharge electrode, as shown at *B*, or you can use a sheet of metal instead, when the brush discharge will produce large quantities of *ozone*, and this is very refreshing in a sick room. (8) Hold your hand near to the discharge electrode, but still far enough away so that the sparks will not pass between them, and you will get a brush discharge from your hand, as at *B*. (9) String a bare, or an insulated, copper wire a *dozen* or *fifteen* feet long, shorter or

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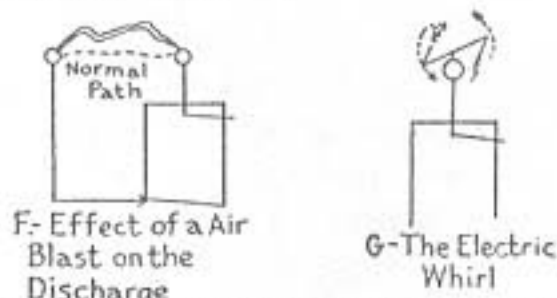


Fig. 180. Some Experiments With High Frequency Currents.

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longer doesn't matter, from a screw eye in the wall to the discharge electrode, as shown at C, when there will be a luminous discharge all along the wire.

(10) Grip one end of a piece of fine iron wire in a pair of pliers and hold the latter tight in your hand; then touch the other and free end of the wire to the discharge electrode of the coil, when the heat of the current flowing through it will melt the wire, but you will not feel any effects from it. The experiment is shown at D. (11) Form a spark gap between the discharge electrodes of the high frequency coil and place a sheet of glass between them, as at E, when the electrostatic stresses set up will puncture the glass.

(12) Set up the discharge between the two discharge electrodes, and pucker up your lips as if you were going to whistle, but instead blow a stream of air on the discharge, when you will observe that it has diverged out of its normal path, as shown at F. (13) Bend a piece of wire a couple of inches long into the shape of the letter Z; make a dent in the middle of it with a center punch and then pivot it on a needle point, which is fixed to the discharge electrode; the wire will whirl round like a static motor and take on the appearance of an electric pinwheel with sparks shooting in streams from the rotating points. (See G, 181.)

(14) Connect each discharge electrode with a sheet of copper, or zinc, about twelve inches on the sides; now place a Geissler tube between the sheets of metal, when it will glow without any direct connection between them, due to the electrostatic field that is set up. The arrangement is shown at H. (15) By con-

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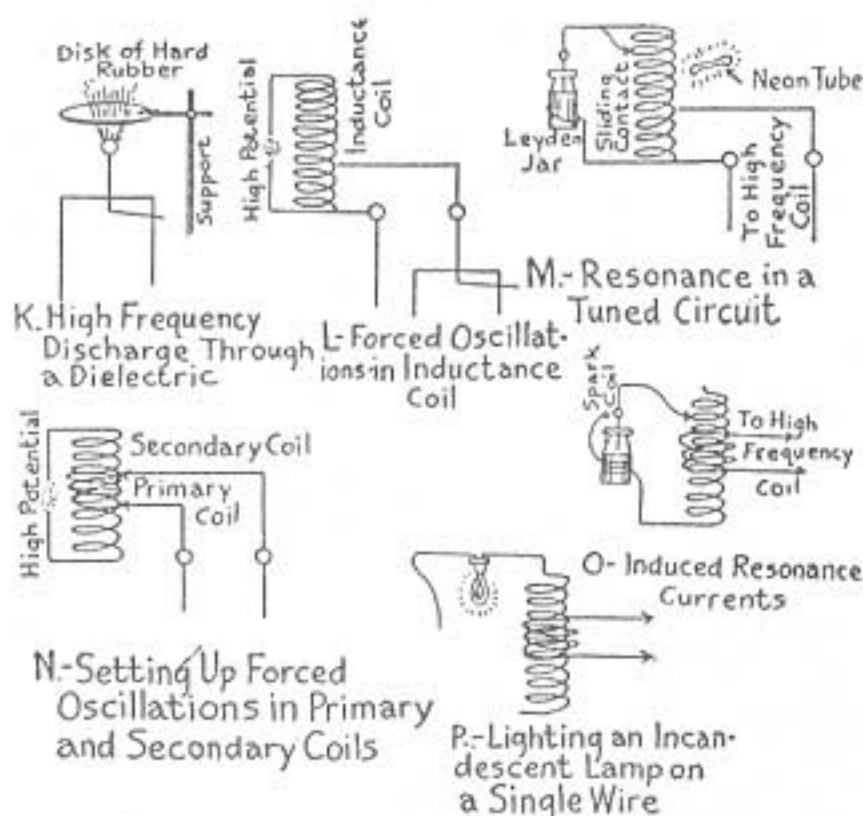
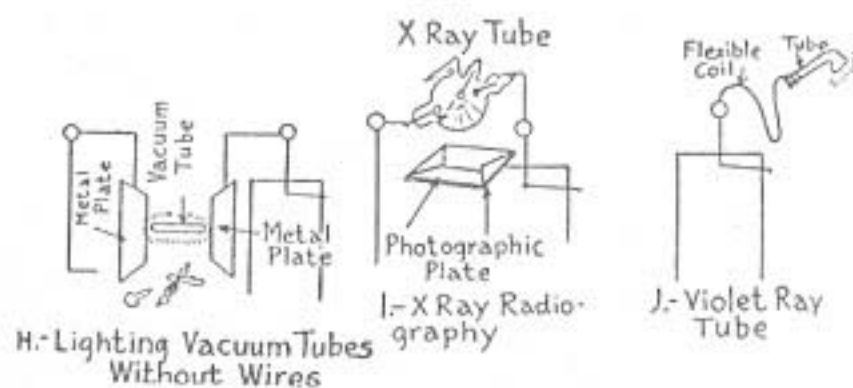


Fig. 181. Some More Experiments With High Frequency Currents.

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necting an X-ray tube to the discharge electrodes of the high frequency coil, as shown at I, it will generate X-rays, when it can be used either with a fluoroscope or for making radiographs.

(16) As a therapeutic agent, high frequency currents, or *violet rays*, as they are more often called in connection with the treatment of maladies, has attained considerable popularity. The *electrode* (See J) is formed of a glass tube with a bulb on one end where it is to be used for surface applications, and from this the air is pumped out. In the smaller size tubes there are no inside wires or metal electrodes of any kind, the only connection between the discharge terminal of the high frequency coil and the glass electrode being that of a contact.

When the flat surface of the electrode is held directly against any part of the body, the tube acts as a condenser and it becomes filled with a cloud-like light, just as a Geissler tube is when it is energized, while the high frequency currents from it will penetrate into the flesh. If you hold the tube one-sixteenth of an inch away from the surface of the body, then the air space between them will be filled with minute sparks.

(17) *Ultra-violet light* is formed of electro-magnetic waves, just as ordinary light is, but it is of such a short wave length that the human eye cannot sense it. Glass cuts off ultra-violet light, while quartz allows it to pass through. Under the action of ultra-violet light certain substances, as, for instance, quinine,

will become beautifully fluorescent. Ultra-violet light, or more properly, *radiation*, can be easily set up by causing a high frequency discharge to take

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place in a spark gap formed between two iron or steel balls.

(18) The high frequency discharge will readily pass through a sheet of insulating material, or *dielectric*, as it is called, and you can show this by supporting a disk of thin hard rubber or glass, on a stand so that it will be directly over the discharge electrode of your high frequency coil, when you can see the brush discharge above the disk, as shown at *K*.

(19) There are a series of experiments in which still another high frequency coil is used, and to differentiate between the D'Arsonval and Tesla coils which you have been using and this new coil, I will call the latter an *inductance coil*. To make this coil, wind a single layer of No. 20 or 22 bare copper wire on a pasteboard tube about two inches in diameter and twelve inches long, and have the turns separated by about one-sixteenth of an inch; this you can do by winding a cord between the turns as you go along. This done, bring the ends of the coil close together, and then connect the last three or four turns at one end of the discharge electrodes of your high frequency coil, as shown at *L*, when high frequency and high potential (voltage) sparks will fill the gap between the discharge electrodes of your inductance coil. In other words, you have *stepped up* the already high potential by setting up *forced oscillations* in the inductance coil.

(20) If you will connect the last three or four turns of the inductance coil to the discharge electrodes of your high frequency coil, as in the preceding experiment, then connect one end of the inductance coil with the outside coating of the Leyden jar and the inside

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coating to the sliding contact of the inductance coil, as shown at *M*, you can now by sliding the contact along the turns of wire, be able to show the resonance of a closed circuit. This you can do by holding a Geissler tube, or, much better, because it is a great deal more sensitive, a *neon* tube, close to the coil, when it will shine brightly on the resonant point being reached.

(21) Now make a *primary* inductance coil by winding three or four turns of insulated copper wire (lamp cord will do) two inches high and about three inches in diameter, and slip this over the inductance coil, described in *Experiment 20*, which now becomes the *secondary* coil; connect the ends of the primary coil to

the discharge electrodes of your high frequency coil, as shown at *N*, when you will get both primary and secondary *forced oscillations* in the coils.

(22) To set up primary and secondary induced *resonance* currents in the primary and secondary inductance coils, connect the primary coil of the latter with the discharge electrodes of the high frequency coil; then connect one end of the secondary inductance coil with the outside coating of a small Leyden jar and the movable contact, which makes connection with the turns of wire at the other end of the coil, with the inside coating of the jar; finally, form a spark gap between the outside and inside of the Leyden jar, as shown at *O*.

(23) A very striking experiment, because to those who are not versed in the art of high frequency currents it seems paradoxical, is to light up an incandescent lamp through your body, as shown at *P*. Connect

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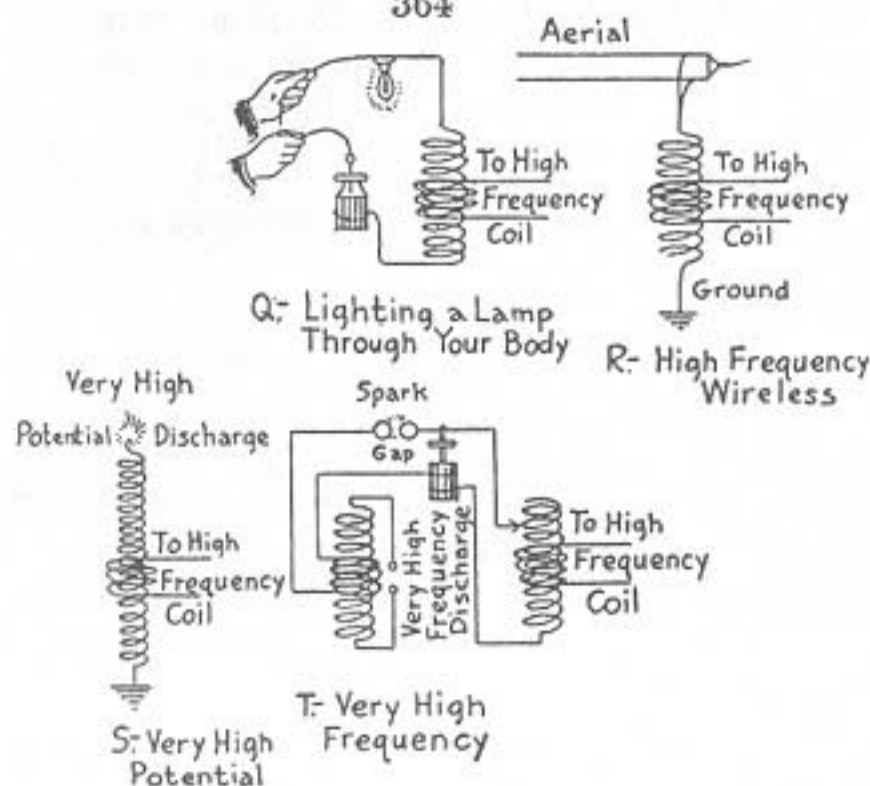


Fig. 182. Four Final Experiments With High Frequency Currents.

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one end of the inductance coil to the outside of the Leyden jar, as in the preceding experiment, and then connect the sliding electrode with one screw of the socket of an incandescent lamp, and a short length of wire to the other screw; this done, connect a wire to the inner coating of the Leyden jar. Now hold the free end of the latter with one hand and the free end of the wire that connects with the lamp with your other hand, when the filament will be heated to brilliancy, as the wireless operators say of vacuum tubes.

(24) To light an incandescent lamp on a single wire, you need only to connect one end of the secondary coil of the inductance coil to a water pipe, or a metal pipe or rod driven in the ground, or a metal plate buried in the earth, and connect the other end of the coil to a lamp, as described in the foregoing experiment and shown at *Q*, when the lamp will light up as before.

(25) To show that wireless messages can be sent with high frequency currents, connect one end of the secondary of the inductance coil to the earth, as described in the experiment ahead of this one, and the other end of it to an aerial wire (See Chapter XIX), as pictured at *R*.

(26) A pretty experiment for showing the effects of very high voltage is to make a cardboard tube, or get a piece of wood turned, so that it will have a diameter of two inches and a length of three or four feet, and give it several coats of shellac varnish. When it is dry wind on a single layer of No. 18 or 20 double-cotton-covered magnet wire; slip the primary inductance coil over the helix of wire and connect one side

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of the latter with a water pipe, a pipe, or rod, or plate in the earth, as described in *Experiment 25*. The

electric effluvia will now issue forth from all parts of the coil, but especially from the free end, as shown at *S*.

(27) To produce currents of very high frequency, make two primary and two secondary inductance coils. Now connect the ends of the primary of one coil with the discharge electrodes of your high frequency coil; next connect one end of the secondary of one coil to the outside coating of a small Leyden jar, and the sliding contact of the secondary coil to the inside coating of the Leyden jar.

This done, connect the inside coating of the jar to one electrode of a spark gap, the other electrode of the latter to one end of the other primary inductance coil, and connect the other end of this to the outside coating of the jar; finally, make a spark gap of the two free ends of the other secondary inductance coil. When you have all of these connections made, you will get currents of enormous frequency set up in the last named secondary inductance coil, and these will discharge across the spark gap, as shown at *T*.

These are only a few suggestive experiments which you as an amateur can make until you become familiar with your apparatus.

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APPENDIX

(READ THIS)

A DICTIONARY OF ELECTRICAL TERMS AND PHRASES

Everybody is interested in electricity, but the ordinary reader, and particularly the boy who attempts to use this manual intelligently, will come across many technical words and terms that require explanation. It would be impossible to incorporate all needful definitions in the text proper, and the reader is therefore referred to the technical dictionary on the succeeding pages.

Care has been taken in its compilation to make the definitions complete, simple, and concise. Some of the more advanced technical terms have been purposely omitted as not necessary in a book dealing with elementary principles. The student in the higher branches of the science will consult, of course, the more advanced text-books. But for our practical purposes this elementary dictionary should answer every requirement. To read it over is an education in itself, and the young experimenter in electrical science should always refer to it when he comes across a word or phrase that he does not fully understand.

A

A. An abbreviation for the word anode.

Absolute. Complete by itself. In if it is graduated to read direct am- quantities it refers to fixed units. A peres or volts. An absolute vacuum galvanometer gives absolute readings is one in which all residual gases are

exhausted; an absolute void is the theoretical consequent. The absolute unit of current is measured in one, two, three, or more amperes or volts.

A-C. An abbreviation expressing alternating current.

Acceleration. The rate of change in velocity.

The increase or decrease of motion when acted upon by the electric current.

Accumulator. A term applied to a secondary battery, commonly called a storage-battery.

Accumulator, Electrostatic. (See Electrostatic Accumulator.)

Accumulator, Storage. A storage-battery.

Acid. A compound of hydrogen capable of uniting with a base to form salts.

Sour, resembling vinegar.

A sharp, biting fluid.

Acidometer. A hydrometer used to determine the gravity of acids. It is employed chiefly in running

storage-batteries to determine when the charge is complete.

Adapter. A screw-coupling to engage with different size screws on either end, and used chiefly to connect incandescent lamps to gas-fixtures.

Adherence. The attraction between surfaces of iron due to electromagnetic action. The term is used in connection with electric brakes—electro-magnetic adherence.

Adjustment. Any change in an apparatus rendering it more efficient and correct in its work.

Aerial Conductor. A wire or electric conductor carried over house-tops or poles, or otherwise suspended in the air, as distinguished from underground or submarine conductors.

Affinity. The attraction of atoms and molecules for each other, due to chemical or electrical action.

Air-condenser. A static condenser whose dielectric is air.

Air-line Wire. In telegraphy that portion of the line-wire which is strung on poles and carried through the air.

Alarm, Burglar. A system of circuits with an alarm-bell, the wires of which extend over a house or building, connecting the windows and doors with the annunciator.

Alarm, Electric. An appliance for calling attention, generally through the ringing of a bell or the operating of a horn.

Alarm, Fire and Heat. An expansion apparatus that automatically closes a circuit and rings a bell.

Alive, or "Live." A term applied to a wire or circuit that is

charged with electricity. A "live" wire.

Active circuits or wires.

Alloy. Any mixture of two or more metals making a scientific compound. For example: copper and zinc to form brass; copper, tin, and zinc to form bronze; copper, nickel, and zinc to form German-silver.

Alternating Current. (See Current, Alternating.)

Alternating Current-power. Electrical distribution employing the alternating current from dynamos or converters.

Alternation. A change in the direction of a current; to and fro. Alternations may take place with a frequency ranging from 500 to 10,000 or more vibrations per second.

Alternator. An electric generator-dynamo supplying an alternating current.

Amalgam. A combination of mercury with any other metal.

Amalgamation. The application of mercury to a metal, the surface of which has been cleansed with acid. Mercury will adhere to all metals, except iron and steel, and particularly to zinc, which is treated with mercury to retard the corrosive action of acid on its surface.

Amber. A fossil resin, valuable only in frictional electric experiments. Most of it is gathered on the shores of the Baltic Sea between Königsberg and Memel. It is also found in small quantities at Gay Head, Massachusetts, and in the New Jersey green sand. When rubbed with a cloth it becomes excited with negative electricity.

Ammeter. The commercial name for an ampere-meter. An instrument designed to show, by direct reading, the number of amperes of current which are passing through a circuit.

Ampere. The practical unit of electric current strength. It is the measure of the current produced by an electro-motive force of one volt through a resistance of one ohm.

Ampere-currents. The currents theoretically assumed to be the cause of magnetism.

Ampere-hour. The quantity of electricity passed by a current of one ampere in one hour. It is used by electric light and power companies as the unit of energy supplied by them, and on which they base their reckoning for measuring the charges for current consumed.

Ampere-ring. A conductor forming a ring or circle. Used in electric balances for measuring current.

Animal Electricity. A form of

electricity of high tension generated in certain animal systems—the Torpedo, Gymnotus, and Célurus. The shocks given by these fish, and particularly the electric eel, are often very severe.

Annealing. The process of softening yellow metals by heating them to a cherry redness, then allowing them to cool gradually in the air.

Electric annealing is done by passing a current through the body to be annealed, and heating it to redness; then allowing it to cool gradually.

Annunciator. An apparatus for giving a call from one place to another, as from a living-room to a hotel office, or for designating a window or door that may have been opened when protected by a burglar-alarm.

Annunciator-drop. The little shutter which is dropped by some forms of annunciators, and whose fall discloses a number or letter, designating the location from which the call was sent.

Anode. The positive terminal in a broken, metallic, or true conducting circuit.

The terminal connected to the carbon-plate of a battery, or to its equivalent in any other form of electric generator, such as a dynamo or a voltaic pile.

The copper, nickel, gold, or silver plates hung in an electro-plating bath, and from which the metal is supplied to fill the deficiency made by the electro-deposition of metal on the kathode or negative object in the bath.

Anti-hum. A shackle inserted directly in a line-wire near a pole. It is provided with a washer or cushion of rubber to take up the vibrations of a wire. To continue the circuit a bridle, or curved piece of wire, is connected with the line-wires that are attached to the shackle.

Arc. A term applied to an electric current flowing from carbon to carbon, or from metals separated by a short gap, as in the arc street-lamps.

The original arc was produced by two vertical rods, through which the current passed up and down. When not in action the upper ends touched, but as the current flowed the ends were separated, so that the current, passing up one carbon across the gap and down the other, formed the segment of a circle in jumping from one tip to the other.

An arc of electric flame is of brilliant and dazzling whiteness. The voltaic arc is the source of the most intense heat and light yet produced

by man. The light is due principally to the incandescence of the ends of carbon-pencils, when a current of sufficient strength is passing through them and jumping over the gap. Undoubtedly the transferred carbon particles have much to do with its formation. The conductivity of the intervening air and the intense heating to which it is subjected, together with its coefficient of resistance, are other factors in the brilliant light produced.

Arc-lamp. An electric lamp which derives its light from the voltaic arc, by means of carbon-pencils and a current jumping from one to the other.

Arc, Quiet. An arc free from the hissing sound so common in arc-lights.

Arc, Simple. A voltaic arc produced between only two electrodes.

Armature. A body of iron or other material susceptible to magnetization, and which is placed on or near the poles of a magnet.

That part of an electric mechanism which by magnetism is drawn to or repelled from a magnet.

The core of a dynamo or motor which revolves within the field magnets, and which is the active principle in the generation of current by mechanical means, or in the distribution of power through electrical influence. Armatures are sometimes made of steel, and are permanent magnets. These are used in magneto-generators, telegraph instruments, and other apparatus.

Armature-bar. An armature in a dynamo or motor whose winding is made up of conductors in the form of bars.

Armature-coil. The insulated wire wound around the core of the armature of an electric current-generator or motor.

Armature-core. The central mass of iron on which the insulated wire is wound; it is rotated in the field of an electric current-generator or motor.

Armored. Protected by armor; as cables may be surrounded by a proper sheathing to guard them from injury.

Astatic. Having no magnetic directive tendency, the latter being a general consequent of the earth's magnetism.

Astatic Circuit. (See Circuit, Astatic.)

Astatic Couple. (See Couple, Astatic.)

Astatic Needle. A combination of two magnetic needles so adjusted as to have as slight directive tendency as possible. The combination is

generally made up of two needles arranged one above the other with the poles in opposite directions—commonly called "Nobili's Pair." These needles require but a slight electro-force to turn them one way or the other, and are used in astatic galvanometers.

Atmospheric Electricity. (See Electricity, Atmospheric.)

Atom. The ultimate particle or division of an elementary substance. Electricity is largely responsible for the presence of atoms in the atmosphere.

Atomic Attraction. The attraction of atoms for each other. Principally due to electric disturbance.

Attraction. The tendency to approach and adhere or cohere which is shown in all forms of matter. It includes gravitation, cohesion, adhesion, chemical affinity, electro-magnetic and dynamic attraction.

Aurora. A luminous electric display seen in the northern heavens. It is commonly thought to be the electric discharges of the earth into the atmosphere, due to revolution of the former and to the heat produced at the equator. As compared to the static machine for generating frictional electricity, the earth represents the revolving wheel gathering the current and discharging it at the poles.

Automatic Cut-out. An electromagnetic switch introduced into a circuit, so as to break the circuit of the latter should it become overloaded with current; it also acts in the event of a mechanical interruption.

Automatic Regulation. A speed regulator worked by electricity so that a uniform flow of current may be secured automatically.

Ayrton's Condenser. This is a pile of glass plates separated by small pieces of glass at the four corners, so that the plates cannot touch each other. Tin-foil is pasted on both sides of every plate, and the two coatings are connected. The tin-foil on each second plate is smaller in area than that on the others, and the plates are connected in two sets, negative and positive. In this construction it will be seen that the glass is not the dielectric proper, but acts only as the plane to which the tin-foil is pasted. One set of plates are connected to a binding-post by strips of tin-foil, and the other set are connected to another binding-post in a similar manner.

B

B. An abbreviation for Beaumé,

the inventor of the hydrometer scale. Thus, in speaking of the gravity of fluids, 20° B. means twenty degrees Beaumé.

Back Induction. A demagnetizing force produced in a dynamo when a lead is given to the brushes. (See also Induction, Back.)

Back Shock. A lightning stroke received after the main discharge. It is caused by a charge induced in neighboring surfaces by the main discharge.

Bad Earth. A poor ground connection, or one having comparatively strong electrical resistance.

Balance. A proper adjustment between the apparatus and the electromotive force, thus securing the best possible results.

B. & S. W.-G. Abbreviations for Brown & Sharp and wire-gauge, and referring to the sizes of wire and sheet-metal thicknesses that are considered standards in America.

Bar-armature. An armature in which the conductors are constructed of bars.

Bare-carbons. Electric light carbons whose surfaces are not electroplated with copper.

Bar-magnet. One whose core presents the appearance of a straight bar, or rod, without curve or bend.

Barometer. An apparatus for measuring the pressure exerted by the atmosphere. It consists of a glass tube 31 inches long, closed at one end, filled with mercury, and then inverted, with its open end immersed in a cistern of mercury. The column of mercury falls to a height proportional to the pressure of the atmosphere. At the sea-level it ranges from 30 to 31 inches.

Bar-windings. The windings of an armature constructed of copper bars.

Bath. In electro-plating, the solution or electrolyte used for depositing metal on the object to be plated. It may be a solution of copper, silver, nickel, or other metal.

In electro-therapeutics it is a bath of water with suitable electrodes and connections for treating patients with electricity.

Bath-stripping. A solution used for stripping or removing the metal plating from an object.

Batten. A strip of wood grooved longitudinally, in which electric light or power wires are set. The grooved strip is screwed to the wall, the wires being laid in the grooves, and then covered with a thin wooden strip fastened on with small nails.

Battery. A combination of parts, or elements, for the production of electrical action.

A number of cells connected parallel or in series for the generation of electricity. Under this heading there are at least one hundred different kinds. Nowadays the dynamo is the cheap and efficient generator of electricity.

Battery Cell, Elements of. The plates of zinc and carbon, or of zinc and copper, in a cell are called elements. The plate unattacked by the solution, such as the carbon or copper, is the negative element, while the one attacked and corroded by the electrolyte is the positive.

Battery, Dry. A form of open circuit cell in which the electrolyte is made practically solid, so that the cell may be placed in any position. A zinc cup is filled with the electrolyte and a carbon-rod placed in the middle, care being taken to avoid contact between cup and carbon at the bottom of the cell. The gelatinous chemical mass is then packed in closely about the carbon, so as to nearly fill the cup. A capping of asphaltum, wax, or other non-conducting and sealing material is placed over the electrolyte, and this hardens about the carbon and around the top inner edge of the zinc cup. The latter becomes the positive pole, the carbon the negative. Binding-posts, or connections, may be attached to the zinc and carbon to facilitate connections.

Battery, Galvanic. The old name for a voltaic battery.

Battery, Gravity. A battery in which the separation of fluids is obtained through their difference in specific gravity—for example, the bluestone cell. The sulphate of copper solution, being the more dense, goes to the bottom, while the zinc solution stays at the top. In its action the acid at the top corrodes the zinc, while at the bottom the solution is decomposed and deposits metallic copper on the thin copper plates.

Battery, Leclanché. An open circuit battery consisting of a jar, a porous cup, and the carbon and zinc elements, the electrolyte of which is a solution of ammonium chloride (sal-ammoniac). The carbon plate is placed in the porous cup, and packed in with a mixture of powdered manganese binoxide and graphite, to serve as a depolarizer. A half-saturated solution of sal-ammoniac is placed in the outer jar, and a rod of zinc suspended in it. Another form of the battery is to omit the porous cup and use twice the bulk of carbon, both elements being suspended in the one solution of sal-ammoniac; this form of bat-

tery is used for open-circuit work only, such as bells, buzzers, and annunciators. It is not adapted for lights, power, or plating purposes.

Battery Mud. A deposit of mud-like character which forms at the bottom of gravity batteries, and which consists of metallic copper precipitated by the zinc. It only occurs where wasteful action has taken place.

Battery of Dynamos. A term used in speaking of a number of dynamos coupled to supply the same circuit. They may be coupled in series or parallel.

Battery, Plunge. A battery in a cabinet or frame, so arranged that the active plates can be removed or raised out of the solutions. This is usually accomplished by having the plates attached to a movable frame which, by means of a ratchet-shaft and chains, can be raised or lowered. Its object is to prevent the corrosion of the plates when not in use.

Battery, Primary. A voltaic cell or battery generating electric energy by direct consumption of material. The ordinary voltaic cell, or galvanic battery, is a primary battery.

Battery, Secondary. A storage-battery, an accumulator.

Battery Solution. The active excitant liquid, or electrolyte, placed within a cell to corrode the positive element. Also called *Electro-poison*.

Battery, Storage. A secondary battery; an accumulator; a battery which accumulates electricity generated by primary cells or a dynamo.

Battery-gauge. A galvanometer used for testing batteries and connections. It is usually small in size, and may be carried in a pocket.

Battery-jar. A glass, earthen, or lead vessel which contains the fluids and elements of each separate cell of a battery.

Baumé Hydrometer. (See Hydrometer, Baumé.)

Becquerel Ray and Radiation. An invisible ray discovered by Becquerel, which is given out by some compounds and chemicals—notably uranium—and which has the power to penetrate many opaque bodies and objects impenetrable to the actinic rays of ordinary light. These rays are used chiefly in connection with the photographic dry-plate.

Bell, Electric. A bell rung by electricity. The current excites an electro-magnet, attracting or releasing an armature which is attached to a vibrating or pivoted arm, on the end of which the knocker is fastened.

Bichromate of Potash. A strong, yellowish-red chemical, used chiefly in battery fluids and electrolytes.

Bifilar Winding. The method followed in winding resistance-coils. To prevent them from creating fields of force, the wire is doubled and the looped end started in the coil. Since the current passes in opposite senses in the two lays of the winding, no field of force is produced.

Binding. Unattached wire wound round armature-coils to hold them in place.

Binding-post. An arrangement for receiving the loose ends of wires in an electric circuit and securing them, by means of screws, so that perfect contact will be the result.

Bi-polar. Possessing two poles.

Bi-telephone. A pair of telephones arranged with a curved connecting arm or spring so that they can be simultaneously applied to both ears.

Blasting, Electric. The ignition of a blasting charge of powder, dynamite, or other high explosive by an electric spark, or by the heating, to red or white heat, of a thin wire imbedded in the explosive.

Block System. A system of signalling on railroads. Signal-posts are arranged at stated spaces, and on these signals appear automatically, showing the location of trains to the engineers of trains in the rear.

Bluestone. A trade name for sulphate of copper in a crystallized state.

Bobbin. A spool of wood or other non-conducting substance wound with insulated wire. In a tangent galvanometer the bobbin becomes a ring with a channel to receive the wire.

Boiling. In secondary, or storage, batteries the escaping of hydrogen and oxygen gases, when the battery is fully charged, resembles water boiling.

Bonded Rails. Rails used in an electric traction system, and which are linked or connected together to form a perfect circuit. Used principally in the third-rail system.

Brake, Electro-magnetic. A brake to stop the wheels of a moving car. It consists of a shoe, or ring, which by magnetic force is drawn against a rotating wheel to stop its revolution.

Branch. A conductor which leads off from a main line to distribute current locally.

Brassing. A process of electro-depositing brass in a bath containing both copper and zinc. A plate of brass is used as an anode.

Brazing, Electric. A process in which the spelter is melted by electric current, so that the two parts are united as one.

Break. A point where an electric conductor is broken, as by a switch or a cut-out.

Bridge. A special bar of copper connecting the dynamos with the bus wire in electric lighting or power stations.

Bronzing. The deposition of bronze by electro-plating methods. The mixture is of copper and tin, and a cast bronze plate is used as an anode.

Brush. A term applied to the pieces of copper, carbon, or other conducting medium in dynamos and motors, that bear against the cylindrical surface of the commutators to collect or feed in the current.

Bug. Any fault or trouble in the connections or workings of an electrical apparatus. The term originated in quadruplex telegraphy, and probably had some connection with the Edison bug-killer that he invented when a boy.

Buoy, Electric. A buoy to indicate dangerous channels in harbors and to mark wrecks and reefs. It is provided with an electric light at night, and with a gong or an electric horn by day.

Burner, Electric. A gas-burner so arranged that the flame may be lighted by electricity operated by a push-button at some distance from the fixture, or, close at hand, by means of a chain or pull-string.

Burning. In a dynamo, the improper contact of brushes and commutator, whereby a spark is produced and an arc formed which generates heat and causes the metal parts to burn.

Bus-rod. A copper conductor used in power-plants to receive the current from the battery of dynamos. The distributing leads are connected to these rods.

Butt-joint. A joint made by bringing the ends of wires together so that the ends butt. They are then soldered or brazed.

Button, Electric. A form of switch that is operated by pushing a button mounted on a suitable base. Used principally for ringing bells, operating lights, etc.

Buzzer. An electric alarm, or call, produced by the rapid vibration of an armature acted upon by electro-magnetism. The sound is magnified by enclosing the mechanism in a resonant box.

An apparatus resembling an electric bell minus the bell and clapper. The buzzer is used in places where

the loud ring of a bell would be a nuisance.

C

C. An abbreviation for centigrade when speaking of thermal temperature. In chemistry the centigrade scale is used extensively, but in air temperatures the Fahrenheit scale is universally employed.

Cable, Aerial. A cable that contains a number of wires separately insulated, the entire mass being protected by an external insulation. It is suspended in the air from pole to pole, and sometimes its weight is so great that a supporting wire is carried along with it (usually overhead), the large cable being suspended from it by cable-hangers.

Cable Box. A box to receive cable ends and protect them; also, the box in which cable ends and line-wires are joined. Submarine cable boxes are usually near the ground, while telephone and telegraph cable boxes are mounted on poles, the cables running from the ground and up the poles to the boxes.

Cable-core. The conductors of a cable which make up its interior mass. For the convenience of line-men the wires are often insulated with different-colored materials so that testing is not necessary when making connections.

Cable-hanger. A metallic grip, usually of sheet metal, arranged to clasp two or more wires. It is fastened to the supporting wire by a hook and eye, or by small bolts with thumb-nuts.

Cable-head. A rectangular board equipped with binding-posts and fuse wires so that the connections may be made between the cable ends and the overhead or line-wires of a system.

Cables. An insulated electric conductor of large diameter, often protected by armor or metallic sheathing, and generally containing, or made up, of several separately insulated wires. Cables supply current to traction lines; power, through subterranean passages; communication, by submarine connection; and light, by overhead or underground conduits.

Call-bell. A bell that is rung by pressing a button, and which is operated by electricity.

Calling-drop. A drop-shutter which is worked by electricity in a telegraph or telephone exchange; it denotes the location from which the call was sent in. Small red incandescent lamps have taken the place of the drops in most of the large telephone exchanges, for they are noise-

less and do not annoy the operators as the drops and buzzers did.

Candle-power. The amount of light given by the standard candle. The legal English and American standard is a sperm candle burning two grains a minute.

Candle, Standard. The standard of illuminating power; a flame which consumes two grains of sperm wax per minute, and produces a light of a brightness equal to one candle-power.

Caoutchouc. India-rubber. So named because originally its chief use was to erase or rub off pencil marks. It is a substance existing, in a thick fluid state, in the sap or juices of certain tropical trees and vines; it possesses a very high value as an insulator for wire and circuits. The unworked, crude rubber is called virgin gum, but after it is kneaded it is called masticated or pure gum rubber.

Capacity. A term used when speaking of the carrying power of a wire or circuit. The capacity of a wire, rod, bar, or other conductor is sufficient so long as the current does not heat it. Directly electric heat is generated, we speak of the conductor as being overloaded or having its capacity overtaxed.

Capacity of a Telegraph Conductor. The electric capacity may be identical in quality with that of any other conductor. In quantity it varies not only in different wires, but for the same wire under different conditions. A wire reacting through the surrounding air, or other dielectric, upon the earth represents one element of a condenser, the earth in general representing the other. A wire placed near the earth has greater capacity than one strung upon high poles, although the wires may be of identical length and size and of the same metal. The effect of high capacity is to retard the transmission of current, the low capacity facilitates transmission.

Capacity, Storage. In secondary batteries, the quantity of electric current they can supply, when fully charged, without exhaustion. This capacity is measured or reckoned in ampere-hours.

Carbon. One of the elements in graphitic form used as an electric-current conductor. It is the only substance which conducts electricity, and which cannot be melted with comparative ease by increase of current. It exists in three modifications—charcoal, graphite, and the diamond. In its graphitic form it is used as an electro-current con-

ductor, as in batteries and arc-light electrodes, and as filaments in incandescent lamps. In arc-lamp use the carbons are usually electroplated on the outside with a film of copper which acts as a better conductor.

Carbon, Artificial. Carbon-dust, powdered coke, or gas carbon is mixed with molasses, coal-tar, syrup, or some similar carbonaceous fluid, so that the mass is plastic. It can then be moulded or pressed into shapes, and heated to full redness for several hours by artificial or electric heat. For lamp-carbons the mixture is forced through a round die by heavy pressure, and is cut into suitable lengths, then fired or baked.

After removing and cooling, the carbons are sometimes dipped again into the fluid used for cementing the original mass and re-ignited. This process is termed "nourishing." All carbon is a resisting medium, but at high temperature the resistance is only about one-third as great; that is, the current will pass through a red-hot carbon three times better than through the cold carbon; or a current of thirty amperes will be conducted as easily through a hot carbon as ten amperes through a cold one.

Carbon-cored. A carbon for arc-lamps, the core being of softer carbon than the outer surface. It is supposed to give a steadier light, and fixes the position of the arc.

Carbon-dioxide. A compound gas, or carbonic-acid gas. It is a dielectric.

Carbon-holders. In arc-lamps, the clamps arranged to hold the carbon-pencils.

Carbonization. The ignition of an organic substance in a closed vessel, so as to expel all constituents from it except the carbon.

A destructive distillation.

Carbon Resistance. (See Resistance, Carbon.)

Carbon Volatilization. In arc-lamps the heat is so intense that it is believed a part of the carbon-pencil is volatilized, as vapor, before being burned or oxidized by the oxygen of the air.

Carbons, Bare. (See Bare Carbons.)

Carrying Capacity. In a current-conductor, its carrying capacity up to the heating-point. It is expressed in amperes.

Cascade. The arrangement of a series of Leyden-jars in properly insulated stools, or supports, for accumulating frictional electricity. They are arranged in a manner somewhat similar to a battery of galvanic cells, the inner coating of one being connected to the outer coating of

the next, and so on through the series.

Case-hardening, Electric. A process by which the surface of iron is converted into steel by applying a proper carbonaceous material to it while it is being heated by an electric current.

Cautery, Electric. An electro-surgical appliance for removing diseased parts or arresting hemorrhages. It takes the place of the knife or other cutting instrument. It is a loop of platinum wire heated to whiteness by an electric current.

C.C. An abbreviation commonly used for cubic-centimeter. It is usually written in small letters, as 50 c.c., meaning 50 cubic-centimeters.

Cell, Electrolytic. A vessel containing the electrolyte used for electro-plating.

Cell, Regenerated. A cell restored to its proper functions by a process of recharging.

Cell, Standard. Meaning the same as battery. The vessel, including its contents, in which electricity is generated.

Cell, Storage. Two plates of metal, or compounds of metal, whose chemical relations are changed by the passage of an electric current from one plate to the other through an electrolyte in which they are immersed.

Cements, Electrical. Cements of a non-conducting nature, such as marine glue and sticky compounds, used in electrical work.

Centrifugal Force. A diametric revolving force which throws a body away from its axis of rotation. A merry-go-round is a simple example of this force. The more rapidly the platform revolves the greater the tendency for those on it to be thrown off and out from the centre. The high velocity attained by the armatures in motors and dynamos would throw the wires out of place and cause them to rub against the surfaces of the field-magnets. Consequently, wire bands or binders are necessary to keep the coils of wire from spreading under the influence of the centrifugal force.

Charge. The quantity of electricity that is present on the surface of a body or conductor.

The component chemical parts that are employed to excite the elements of a cell in generating electric current.

Charge, Residual. After a Leyden-jar, or other condenser, has been discharged by the ordinary methods, a second discharge (of less amount) can be had after a few minutes' waiting. This is due to

what is known as the residual charge, and is connected in some way with the molecular distortion of the dielectric.

Chemical Change. When bodies unite so as to satisfy affinity, or to bring about the freeing of thermal or other energy, the union is usually accompanied by sensible heat or light. Sulphuric acid added to water produces heat; a match in burning produces light. Another form of chemical change is decomposition or separation (the reverse of combination), such as takes place in the voltaic-battery, the electro-plating bath, and other forms of electrolysis. This is not accompanied by heat or light, but by the evolution of electricity.

Chemical Element. (See Element, Chemical.)

Chemistry. The science which treats of the atomic and molecular relations of the elements and their chemical compounds. Chemistry is divided into many departments, but electro-chemistry treats only of the science wherein electricity plays an active part, such as batteries, electro-plating, and electro-metallurgy.

Choking-coil. (See Coil, Choking.)

Circle, Magic. A form of electro-magnet. It is a thick circle of round iron used in connection with a magnetized coil to illustrate electro-magnetic attraction.

Circuit. A conducting-path for electric currents. Properly speaking, a complete circuit has the ends joined, and includes a source of current, an apparatus, and other elements introduced in the path. When the circuit is complete it is called active. The term circuit is also applied to portions of a true circuit—as, an internal or external circuit.

Circuit, Astatic. A circuit so wound, with reference to the direction of the currents passing through it, that the terrestrial or other lines of force have no directive effect upon it.

Circuit-breaker. Any apparatus for opening and closing a circuit, such as switches, automatic cut-outs, lightning-arresters, and the like.

A ratchet-wheel engaged with a spring, or wire, which rests against the teeth. The current passes through the wire, the wheel, and axle. The wheel is revolved by a crank, and as the ratchets pass the spring, or wire, an instantaneous make-and-break occurs. The speed of the wheel regulates the frequency of the interruptions.

Circuit, External. A portion of the circuit not included within the generator, such as a secondary tele-

graph key and sounder.

Circuit, Grounded. A circuit in which the ground is used as a conductor. This is common in telegraph and telephone lines, particularly for short distances where the conductivity of the earth does not offer too much resistance.

Circuit, Incandescent. A circuit in which incandescent lamps are installed.

Circuit Indicator. A pocket-compass, galvanometer, or other device for indicating or detecting the condition of a wire, whether it is active or dead, and, if active, in which direction the current is flowing. It may also give a general idea of its strength.

Circuit, Internal. That portion of an electric circuit which is included within the generator.

Circuit Loop. A minor circuit introduced, in series, into another circuit by a switch or cut-out, so that it becomes a part of the main circuit.

Circuit, Main. A circuit, or main line, includes the apparatus supplying current to it. Thus distinguished from a local circuit.

Circuit, Metallic. A circuit in which the current outside the generator passes through metal parts or wire, but not through the ground. Electric light and power lines are always metallic circuits. An electro-plating apparatus may be properly termed a metallic circuit, although a part of the circuit is formed by the electrolyte in the bath. The essential meaning of the words metallic circuit is that the earth does not form a part of the return circuit.

Circuit, Open. A circuit in which a switch has been opened to prevent the continuous flow of current, such as an electric-bell circuit, which normally remains open, and which is active only when the push-button is pressed, thereby closing the circuit and operating the bell. An open-circuit battery is one that remains inactive when the circuit is open.

Circuit, Parallel. A term signifying a multiple circuit.

Circuit, Quadruple. A single circuit capable of having four messages transmitted over it simultaneously—two in one direction, and two in the other.

Circuit, Return. In telegraphy the ground is used as the return circuit. It is also that portion of a circuit which leads from an apparatus back to the terminal of a dynamo or battery, usually the negative wire.

Circuit, Short. A connection between two parts of a circuit, causing the current to skip a great part of

its appointed path. Short-circuits prevent the proper working of any electrical apparatus.

Circuit, Simple. A circuit containing a single generator, the proper wire for carrying the current, and a switch to operate it. An electric-bell line, a single telegraph line, or a direct telephone line are all simple circuits.

Clamp. A tool for grasping and holding the ends of wires while joining them.

The appliance for holding the carbon-pencils in arc-lamps.

Cleats. Blocks of wood, porcelain, or other insulating material used to hold wires against a wall or beam. They have one, two, and three notches at one side, for single, double, and three wire systems.

Clutch, Electric. A form of magnetic brake applied to car-wheels, the armatures of motors, and other revolving mechanism, whereby the current, passing through a coil, magnetizes a mass of cast-iron, and brings it to bear frictionally upon the moving parts of the mechanism.

Code, Cipher. A set of disconnected words which, in accordance with a prearranged key, stand for whole sentences and phrases. Commercially the system is used as a short-cut—ten words perhaps meaning what otherwise it would take forty or fifty words to express. It is used extensively in telegraphy, both as an abbreviated message and as a means for securing secrecy.

Coherer. Conducting particles constituting a semi-conducting bridge between two electrodes, and serving to detect electro-magnetic waves. The coherer in wireless telegraphy is understood to mean that form of radio-receiver which, being normally at high resistance, is, under the influence of Hertzian-waves, changed to a low resistance, thus becoming relatively a conductor. Tubes of various kinds have been used for this purpose. Within them is a filling of carbon granules, copper filings, nickel and silver filings, and other substances. Marconi's coherer consists of a tube one and one-half inches long and one-twelfth inch internal diameter. This is filled with filings—90 per cent. of nickel, 10 per cent. of silver. A globule of mercury coats the outer surface of each grain with a thin film of the quicksilver. Into both ends a piece of pure silver wire is plugged. These latter are a quarter of an inch long, and fit the tube very accurately. The tube is thus sealed, and it is considered preferable to have a slight vacuum with-

in it.

Coil. A strand of wire wound in circular form about a spool, a soft-iron core, or in layers, as a coil of rope.

An electro-magnetic generator.

A helix. (See also Induction, Resistance, Magnetizing.)

Coil, Choking. A form of resistance to regulate the flow of current. Any coil of insulated wire wound upon a laminated or divided iron core forms a choking-coil. In alternating-current work special choking-coils are used. They have a movable iron core, and by thrusting it in or out the power is increased or diminished, thus raising or lowering the lights, the same as gas is regulated.

Coil, Faradic. The name given to a medical induction-coil or faradic machine.

Coil, Induction. A coil in which the electro-motive force of a portion of a circuit is, by induction, made to produce higher or lower electro-motive forces in an adjacent circuit, or in a circuit a part of which adjoins the original circuit. There are three principal parts to all induction-coils—the core, the primary coil, and the secondary coil. The core is a mass of soft iron, cast or wrought, but preferably divided—for example, a bundle of rods or bars. The primary coil of comparatively larger wire is wound about this core, each layer being properly insulated and varnished, or

coated with melted paraffine, to bind the wires. The secondary coil is of fine wire, and is wound about the primary coil. A great many turns of the fine wire are necessary, and care must be taken to properly insulate each layer and shellac the wires. The primary must be well insulated from the secondary coil, so as to prevent sparking, which would destroy the insulation. A make-and-break is operated by the primary coil, and is constructed upon the general form of an electric bell or buzzer movement. Extra currents which interfere with the action of an induction-coil are avoided by the use of a condenser. (See also Condenser.) The induction-coil produces a rapid succession of sparks which may spring across a gap of thirty or forty inches, according to the size of the coil. Induction-coils are used extensively in electric work, especially in telephone transmitters, wireless telegraphy, electric welding, and in the alternating-current system.

Coil, Magnetizing. A coil of in-

ulated wire so wound that a well or aperture will be formed. Within this well a piece of steel is placed, so that an electric current, passing through the wires, will magnetize the steel; or a steel rod may be passed in and out of the hole several times while a strong current is travelling through the coil, thus magnetizing the rod.

Coil, Resistance. A coil so constructed that it will offer resistance to a steady current of too great electro-motive force for the safety of the apparatus. Generally the coil is made by doubling the wire without breaking it, then starting at the doubled end to wind it in coil or spring fashion. If the wire is too heavy to wind double, a single strand is wound on a square or triangular insulator in which notches are made. Then, alternately between the coils, the second strand is wound. The strands are joined at one end of the coil, but those at the other are left free for unions with other wires. (See also Resistance.)

Coil, Retarding. A choking-coil. A resistance-coil.

Coil Ribbon. Instead of wire, flat, thin strips of sheet-metal are sometimes used for resistance-coils, doubled, as explained above. The wraps are insulated with sheet-mica, micanite, or asbestos, to prevent short-circuiting.

Coil, Ruhmkoff. A common type of induction-coil with a vibrator or circuit-breaker. Used with constant and direct current.

A step-up transformer with a circuit-breaker attachment.

Coils, Idle. Coils in a dynamo in which no electro-motive force is being generated or developed.

Coils that, through broken connections or short circuits, are inactive.

Column, Electric. An old name for the voltaic pile. The apparatus made up of a pile of disks of copper and zinc, separated by pieces of flannel wet with acidulated water.

Comb. A bar from which a number of teeth project like the teeth of a comb. It is used as a collector of electricity from the plate of a frictional electric machine.

Commutator. An apparatus used on motors and dynamos and induction-coils for changing the direction of currents. It is made in a variety of types, but usually in the shape of insulated bars closely packed about an armature shaft.

Commutator-bars. The metallic segments of a dynamo or motor-commutator.

Commutators, Quiet. Commuta-

tors that do not spark during the revolutions of the armature.

Compass. An apparatus for indicating the directive force of the earth upon the magnetic needle. It consists of a case covered with glass, in which a magnetized needle, normally pointing to the north, is balanced on a point at the centre. Under the needle a card is arranged on which the degrees or points of the compass are inscribed. A valuable instrument in electrical work, magnetism, etc.

Compass, Liquid. A form of marine compass. The needle is attached to a card or disk which floats in alcohol or other spirits, so as to check undue oscillation.

Compass, Mariners'. A compass in which the needle is attached to a card that rotates in pointing to the north. A mark, called the "lubber's mark," is made upon the case, and this is in line with the ship's keel, so that a glance at the card will indicate the direction in which the ship is headed.

Compass, Spirit. A form of mariners' compass in which the bowl, or case, is sealed and filled with alcohol. The compass-card works as a spindle, and, by a series of air compartments, floats on the alcohol. The friction of the pivot is thereby greatly diminished, making the compass a very sensitive one.

Compass, Standard. A compass employed as a standard by which to compare other compasses.

Condenser. An appliance for storing up electro-static charges; it is also called a static accumulator. The telegraphic condenser consists of a box packed full of sheets of tin-foil having a sheet of paraffined paper or sheet-mica between every two sheets. The alternate sheets of tin-foil are connected together, and each set has its binding-post. (See also Electrostatic Accumulator.)

Condenser, Air. (See Air-condenser.)

Condenser, Ayrton's. (See Ayrton's Condenser.)

Condenser-plate. (See Plate, Condenser.)

Condenser, Sliding. An apparatus in the form of a Leyden-jar whose coatings can be slid past each other to diminish or increase the face area, and also to diminish or increase the capacity of the condenser.

Conductance. The conducting power of a mass of material, varying according to its shape and dimensions. The cylindrical or round conductor is the best type for the conveyance of electric currents.

Conduction. The transmission of electricity through an immobile medium, such as a wire, or rod, or a bar.

Conductivity. Ability to conduct electric currents. The conductivity of a wire is its power to conduct or transmit a current. Glass has no conductivity, and it is therefore a non-conductor.

Conductivity, Variable. The change in the conducting or transmitting powers of metals and substances under different temperatures. Hot metal conducts an electric current better than cold. A hot carbon-pencil in an arc-light conducts the current better than when the light is first started, for as it warms up under the influence of the arc-flame the current passes more freely. Five minutes after the current is turned on the lamps in the circuit give a steady light, and do not sputter as when they first start up.

Conductor. Anything which permits the passage of electric current. The term conductor is a relative one, and, excepting a vacuum, there is probably no substance that has not some conductive power. Metals, beginning with silver, are the best conductors, liquids next, glass the worst. The ether, or air, is a conductor of sound and electric vibratory disturbances, but not in the same sense as the ground. The air conducts frictional electricity, while the ground acts as a conductor for the galvanic current, or "current electricity." By this last term is meant electricity which flows continually, instead of discharging all at once, with an accompanying spark or flash.

Conductor, Overhead. Overhead electric lines, wires or cables, for conducting current. Generally poles are erected for this purpose.

Conductor, Prime. A cylindrical or spherical body with no points or angles, but rounded everywhere and generally of metal. If made of other material, such as wood, glass, or composition, its entire surface is rendered conductive by being covered with sheet-metal, such as tin-foil, gold-leaf or tinsel, applied to it with paste, shellac, or glue. A prime conductor should be mounted on an insulated stand; it is employed to collect and retain frictional electricity generated by a static machine.

Conductor, Underground. An insulated conductor which is placed under the surface of the earth, passing through conduits.

Connect. The act of bringing two

ends of wire together, either temporarily or permanently. Bringing one end of a conductor into contact with another so as to establish an electric connection.

Connector. A sleeve, with screws or other clamping device, into which the ends of wires or rods may be passed and held securely. A binding-post and spring-jack comes under this head.

Contact. The electrical union of two conductors, whether temporary or permanent. It may be established by touching the ends or terminals of a circuit through the agency of a push-button, a telegraph-key, an electric switch, etc.

Contact-breaker. (The same as Circuit-breaker, *which see*.)

Contact, Loose. A contact formed by two or several surfaces imposed one upon another and held by their weight alone.

Contact-point. A point, or stud, often of silver or platinum, arranged to come into touch with a contact-spring, such as the vibrating armature of an electric bell.

Contact-spring. A spring connected at one end of a lead and arranged to press against another spring or plate, so that a plug may be inserted between the contact-points.

Controller. The lever or handle on the switch-board of a resistance-coil, by means of which electric current is let in or kept out of a circuit.

Controlling Force. In galvanometers and similar instruments, the force used to bring the needle or indicator back to zero.

Converter. An induction-coil used with the alternating current for changing the potential difference and inverting the available current. High alternating voltage may be converted into lower direct-current voltage, thereby increasing the amperage or current. A converter consists of a core of thin iron sheets, wound with a primary coil of fine insulated wire, with many convolutions or turns. Also, a secondary coil made up of coarse insulated wire with fewer convolutions. The coil may be jacketed with iron to increase the permanence.

Converter, Rotary. A combined motor and dynamo whose function is to transform a current of high or low voltage (A-C., or D-C.) into any other kind of current desired.

Convolution. The state of being convolved; a turn, wrap, fold, or whorl. A clock-spring is a familiar example.

Copper-bath. A solution of sulphate of copper used in electro-

plating, electrotyping, and copper-refining by electricity.

Cord, Flexible. A flexible-wire conductor made up of many strands of fine wire and properly insulated so that it may be easily twisted, bent, or wrapped. Flexible wire is used as the conductors for portable electric lights, push-buttons, medical coils, etc.

Core. The iron mass (generally located in the centre of a coil or helix) which becomes highly magnetic when a current is flowing around it, but which loses its magnetism immediately that the current ceases to flow.

A conductor or the conductors of an electric cable made up of a single strand or many strands laid together and twisted. These may be of bare metal, or each one insulated from the others.

Core-disks. Disks of thin wire, for building up armature-cores. The usual form of a core is round or cylindrical. A number of thin disks, or laminations, of iron strung upon the central shaft, and pressed firmly together by the end-nuts or keys. This arrangement gives a cylinder as a base on which to wind the insulated wire that forms a part of the armature.

Core-disks, Pierced. Core-disks for an armature of a motor or dynamo, which have been pierced or bored out around the periphery. Tubes of insulating material, such as fibre, rubber, or paraffined paper, are inserted in the holes and through these the windings of wire are carried. The coils are thus imbedded in the solid mass of iron, and are protected from eddy currents; also they act to reduce the reluctance of the air-gaps. This arrangement is very good, from a mechanical point of view, but in practice its use is confined to small motors only, and dynamos generating under one hundred volts.

Core-disks, Toothed. Core-disks of an armature or motor where notches are cut from the periphery. When they are locked together, to form the armature-core, the coils of wire lie in the grooves formed by a number of the disks bound together. This construction reduces the actual air-gaps and keeps the coils equally spaced.

Core, Laminated. The core of an armature, an induction-coil, a converter, or any similar piece of apparatus, which is made up of plates or disks, insulated more or less perfectly from one another by means of mica or paraffined paper. The object of laminations is to prevent the

formation of Foucault currents. A core built up of disks is sometimes called a radially laminated core.

Core, Ring. A dynamo or motor armature-core which forms a complete ring.

Core, Stranded. The core of a cable, or a conducting core made up of a number of separate wires or strands laid or twisted together.

Core, Tubular. Tubes used as cores for electro-magnets, and also to produce small magnetizing power. Tubular cores are nearly as efficient as solid ones in straight magnets, because the principal reluctance is due to the air-path. On increasing the current, however, the tubular core becomes less efficient.

Coulomb. The practical unit of electrical quantity. It is the quantity passed by a current of one ampere intensity in one second.

Couple. The combination of two electrodes and a liquid, the electrodes being immersed in the latter, and being acted on differentially by the liquid. This combination constitutes a source of electro-motive force, and, consequently of current, and is called the galvanic or voltaic cell or battery.

Couple, Astatic. A term sometimes applied to astatic needles when working in pairs.

Coupling. The union of cells or generators constituting a battery; the volume of current, or electro-motive force, is thereby increased.

C. P. An abbreviation for "candle power"; also meaning "chemically pure," when speaking of chemicals.

Crater. The depression that forms in the positive carbon of a voltaic arc.

Creeping. A phenomena met with in solution batteries. The electrolyte creeps up the sides of the containing jar and evaporates, leaving a deposit of salts. Still more solution creeps up through the salts until it gets clear to the top and runs over. To prevent this the tops of the jars should be brushed with hot paraffine for a distance of two inches from the upper edge. The salts will not form on paraffine. Oil is sometimes poured on the top of the battery solution, but this affects the elements if it touches them, and makes their surfaces non-conducting.

Crucible, Electric. A crucible for melting refractory substances, or for reducing ores by means of the electric arc produced within it. Probably the result obtained is due more to current incandescence than to the action of the arc.

Crystallization, Electric. Under

proper conditions many substances and liquids take a crystalline form. When such action is brought about by means of electricity the term electric crystallization may be applied to the phenomenon. A solution of nitrate of silver, when decomposed by a current, will give crystals of metallic silver. A solution of common salt or brine, when electrically decomposed, will produce sodium and chlorine. The sodium appears at the leading-out electrode and readily unites with carbonic-acid gas, which is injected into the apparatus. The result of the combination is carbonate of soda, one of the most important products of the alkali industry.

Current, Alternating. A current flowing alternately in opposite directions. It is a succession of currents, each of short duration and of direction opposite to that of its predecessor. Abbreviation, A-C.

Current, Amperage. The volume of electricity passing through any circuit per second, the flow being uniform.

Current, Constant. An unvarying current. A constant-current system is one in which the current is uniformly maintained—for example, in electric light, power, and heat plants.

Current, Continuous. A current of one direction only, or the reverse of an alternating current.

Current, Direct. A current of unvarying direction, as distinguished from the alternating. Abbreviation, D-C.

Current Distribution, Uniform. A steady current; a current whose density in a conductor is always the same at all points.

Current, Induced. A current caused by electro-dynamic induction.

Current, Low Potential. A current of low pressure.

A term applied to low electro-motive force.

Current, Make-and-break. A current which is continually broken or interrupted and started again. The term is applied only where the interruptions occur in rapid succession, as in the action of an induction-coil or pole-changer.

The alternating current.

Current-meter. An apparatus for indicating the strength of a current, such as an ammeter.

Current, Oscillating. A current periodically alternating.

Current, Periodic. A current with periodically varying strength or direction. A current alternating periodically.

Current, Polarizing. A current

which causes polarization.

Current-reverser. A switch or other contrivance for reversing the direction of a current in a conductor.

Current, Undulating. A current whose direction is constant but whose strength is continuously varying.

Currents, Eddy. Useless currents in an armature, in the pole pieces, and in the magnetic cores of dynamos and motors. They are created by the high speed of the armature in its rotation, or by other electric currents induced by the armature's motion through magnetic fields.

Currents, Faradic. Induced currents. They take their name from Michael Faraday, the original investigator of the phenomena of electro-magnetic induction. The secondary or induced electro-magnetic currents and their accompanying phenomena.

A series of alternating electro-static discharges from influence machine, such as the Holtz and Wimshurst.

The simple and commonly understood Faradic currents are those produced in the medical battery, and used in medical therapeutics.

Currents, Foucault. A form of currents produced in revolving armature-cores; sometimes called eddy currents. They are useless.

Currents, Harmonic. Currents which alternate periodically, and vary harmonically. Currents which vibrate at certain pitches, as, for instance, the currents in wireless telegraphy. Two instruments must be tuned to the same pitch in order to be responsive. Thus an instrument sending out waves of 70,000 vibrations cannot be recorded by one tuned much below or above the same number.

Sound waves of sympathetic or harmonic vibrations.

Currents, Positive. (See Positive Currents.)

Cut-in. To electrically connect a piece of mechanism or a conductor with a circuit.

Cut-out. The reverse of the cut-in. To remove from a circuit any conducting device. The cut-out may be so arranged as to leave the circuit complete in some other way.

An appliance for removing a piece of apparatus from a circuit so that no more current shall pass through the former.

Cut-out, Automatic. A safety device for automatically cutting out a circuit to prevent accident or the burning-out of an apparatus, due to an overload of current. It is worked by an electro-magnet and

spring. An overload of current causes a magnet of high resistance to draw an armature towards it, and this, in turn, releases the spring of the cut-out device. Sometimes a strip or wire of fusible metal is employed which is in circuit with a switch. The excess of current fuses the metal, and the broken circuit releases a spring-jack, which, in turn, breaks the circuit.

Cut-out, Safety. A block of non-conducting material, such as marble, slate, or porcelain, carrying a safety-fuse or plugs. In these is enclosed a piece of fusible wire, which burns out or melts and breaks the circuit before the apparatus is damaged.

Cut-out, Wedge. A cut-out operated by a wedge, such as a spring-jack or the plugs at the end of the flexible wires on the switch-boards of telephone exchanges.

D

Damper. A frame of copper on which the wire in a galvanometer is sometimes coiled. It acts to check the needle oscillations.

A brass or copper sheathing or tube placed between the primary and secondary coils of an induction-coil to cut off induction and diminish the current and potential of the secondary circuit. When the tube is drawn out gradually the induction increases. It is commonly used in medical coils to adjust their strength of action.

D-C. An abbreviation for direct current.

Dead Earth. A fault in telegraph and telephone lines which consists in the ground-wire being improperly grounded, or not fully connected with the earth.

Dead Turns. A term applied to the ten to twenty per cent. of the convolutions or turns of wire on an armature which are considered to be dead. There are supposed to be about eighty per cent. of the turns on an armature that are active in magnetizing the core; the balance are outside the magnetic field and are termed dead, although they are necessary to the production of electro-motive force.

Dead Wire. A wire in the electric circuit through which no current is passing.

A disused or abandoned electric conductor, such as a telegraph wire, or a wire which may be in circuit, but through which at the time of speaking no electrical action is taking place.

Death, Electrical. Death result-

ing from an electric current passing through the animal body—electrocution; accidental death by electric shock; premeditated death through bringing the body in direct contact with conductors carrying high electro-motive force. High electro-motive force is essential, and the alternating current is most fatal.

Decomposition, Electrolytic. The decomposition or separation of a compound liquid into its constituents by electrolysis. The liquid must be a conductor or electrolyte, and the decomposition is carried on by means of electricity.

The conversion of two or more chemicals into a new compound or substance.

Deflection. In magnetism, the movement of the needle out of the plane. It is due to disturbance, or to the needle's attraction towards a mass of iron or steel or another magnet.

Demagnetization. The removal of magnetism from a paramagnetic substance. The process is principally in use for watches which have become magnetized by exposure to the magnetic field surrounding dynamos or motors.

Density, Electric. The relative quantity of electricity, as a charge, upon a unit area of surface. It may be positive or negative.

Surface density, as the charge of a Leyden-jar.

Depolarization. A term applied to the removal of permanent magnetism, such as that from a horse-shoe magnet, a watch, or a bar-magnet. Heat is the common depolarizer, but counter electro-magnetic forces are employed also in the various forms of apparatus known as demagnetizers.

Deposit, Electrolytic. The metal or other substances precipitated by the action of a battery or other current-generator, as in the plating processes.

Detector. A portable galvanometer, by means of which a current and its approximate strength can be detected and measured.

Diaphragm. In telephones and microphones, a disk of iron thrown into motion by sound-waves or by electric impulse. It is usually a thin plate of japanned iron, such as is used in the ferrotype photographic process for making tin-types.

Dielectric. Any substance through which electrostatic induction is allowed to occur, such as glass or rubber. It is a non-conductor for all electric currents.

Dielectric Resistance. The resistance a body offers to perforation or destruction by an electric discharge.

Dimmer. An adjustable choke or resistance coil used for regulating the intensity of electric incandescent lamps. It is employed extensively in theatres for raising or lowering the brilliancy of lights.

Dipping. The process of cleaning articles by dipping them in acids or caustic soda, preparatory to electro-plating.

Simple immersion, with or without current, to put a blush of metal on a cleaned surface.

Dipping-needle. A magnetic needle mounted on a horizontal bearing so that it will dip vertically when excited by a current passing horizontally about it. The ordinary compass-needle is mounted on a point, and swings freely to the right or left only.

Direct Current. (See Current, Direct.)

Discharge. The eruptive discharge from a Leyden-jar or accumulator of a volume of electricity stored within it.

The abstraction of a charge from a conductor by connecting it to the earth or to another conductor.

Discharge, Disruptive. The discharge of a static charge through a dielectric. It involves the mechanical perforation of the dielectric.

Disconnect. To break an electric circuit or open it so as to stop the flow of current; to remove a part of a circuit or a piece of apparatus from a circuit.

Distillation, Electric. The distilling of a liquid by the employment of electricity, which, by electrifying the liquid, assists the effects of heat. It is asserted that the process is accelerated by the electrification of the liquid or fluid, but it must be a conductor liquid or electrolyte. Oil, being a non-conductor, is not affected by any electric current, no matter what its specific gravity may be.

Distributing Centre. The centre of distribution in a system having branch circuits, such as the electric-light or telephone outlets from a main station.

Door-opener, Electric. A magnetic contrivance arranged in connection with a lock, by means of which the latch is released by pressing a distant push-button. This device is used in flats and apartment-houses for opening a door from any of the apartments in the house.

Double Filament Lamp. An incandescent lamp having two filaments, one with a high capacity, the other with a low one. The high capacity may be from sixteen to

fifty candle-power, the other from one to five. A turn of the bulb in its socket, or the pulling of a string which operates a switch in the socket, cuts out the current from the long filament and sends it through the shorter and finer one, thus giving a weaker light. These "hy-lo" lamps are useful as night lamps in halls, bath-rooms, or in sick-rooms, where a low or weak light is required all night.

Double Pole-switch. A cut-out that is arranged to cut out the circuit of both the negative and positive leads at the same time.

Double-push. A contact-push having two contacts and arranged so that pressure upon it opens one contact and closes the other.

Double Throw-switch. A switch so arranged that it can be thrown into either one of two contacts; a throw-over switch.

Driving-pulley. The broad-faced or channelled pulley on an armature shaft by means of which the power from a motor may be transmitted mechanically.

Dry Battery. (See Battery, Dry.)

Duct. The space in an underground conduit for a single wire or cable.

Duplex Wire. An insulated conductor having two distinct wires twisted or laid together, but properly insulated from each other.

Dynamic Electricity. Electricity in motion or flowing, as distinguished from static or frictional electricity.

Electricity of relatively low potential or electro-motive force in large quantity or amperage.

Dynamo. An apparatus consisting of a core and field-magnets, properly wound with insulated wire, which, when put into operation by revolving the core or armature at high speed, develops electric current; a mechanical generator of electricity.

Dynamo, Motor. (See Motor-dynamo.)

E

Earth. The accidental grounding of a circuit is termed an "earth."

Earth-plate. A plate buried in the ground to receive the ends of telegraph lines and other circuits, and so give a ground connection. Copper plates are often used, but in houses the ground is usually formed by attaching a wire to the gas or water pipes.

Earth Return. The grounding of a wire in a circuit at both ends gives the circuit an earth return. This method is commonly used in telegraph lines, both in the wire

and wireless systems.

Eddy Currents. (See Currents, Eddy.)

Edison Distributing-box. A box used in the Edison "three-wire" system, from which the outlets pass to local circuits.

Edison Lalande Cell. A zinc-copper battery having a depolarizing coating of copper oxide on the copper element, the couple being immersed in an electrolyte composed of potash or caustic soda.

Ediswan. A term applied to the incandescent lamps invented by Edison and Swan and used extensively in Great Britain. Also applied to other apparatus designed by the two inventors.

Efficiency. The relation of work done to the electrical energy absorbed. The efficiency is not equal to the energy absorbed, because it always takes more power to generate a current than is given back in actual efficiency. This is due to mechanical friction and to the resistance of the air in a mechanism such as a dynamo when revolving at high speed.

Efficiency, Electrical. In a generator it is the total electrical energy produced, both that wasted and that actually used in driving machinery or apparatus.

Efflorescence. The dry salts on a jar or vessel containing liquid that collects above the water or evaporation line. This is due to creeping.

Elasticity. A property in some bodies and forces through which they recover their former figure, shape, or dimensions when the external pressure or stress is removed. Water has no elasticity. Air is very elastic; steam has a great volume of elasticity; while electricity is undoubtedly the most elastic of all in its motion through air, water, and other conducting mediums.

Electric. Pertaining to electricity; anything connected with the use of electricity. It has been a much-abused word, and its meaning has been garbled by the impostor, the crook, and the "business thief" in foisting on the public wares in which there was no electrical property whatever. "Electric" tooth-brushes, combs, corsets, belts, and the like may contain a few bits of magnetized steel, but they possess no active therapeutic value.

Electrical Engineer. The profession of electrical engineer calls for the highest knowledge of electricity, both theoretical and practical. It embraces the designing and installation of all kinds of electrical apparatus.

Electrician. One versed in the practices and science of electricity; a practical lineman or wireman.

Electricity. One of the hidden and mysterious powers of nature, which man has brought under control to serve his ends, and which manifests itself mainly through attraction and repulsion; the most powerful and yet the most docile force known to man, coming from nowhere and without form, weight, or color, invisible and inaudible; an energy which fills the universe and which is the active principle in heat, light, magnetism, chemical affinity, and mechanical motion.

Electricity, Atmospheric. The electric currents of the atmosphere, variable but never absent. They include lightning, frictional electricity, the Aurora Borealis, the electric waves used in wireless telegraphy, etc. Benjamin Franklin indicated the method of drawing electricity from the clouds. In June, 1752, he flew a kite, and by its moistened cord drew an electric current from the clouds so that sparks were visible on a brass key at the ground end of the cord. Later, when a fine wire was substituted for the cord, and a kite was flown in a thunder-storm, the electric spark was vivid. This experiment confirmed his hypothesis that lightning was identical with the disruptive discharges of electricity.

Electricity, Latent. The bound charge of static electricity.

Electricity, Negative. (See Negative Electricity.)

Electricity, Positive. (See Positive Electricity.)

Electricity, Voltaic. Electricity of low potential difference and large current intensity.

Electricity produced by a voltaic battery or dynamo as opposed to static electricity, which is frictional and practically uncontrollable for commercial purposes.

Electrification. The process of imparting an electric charge to a surface. The term is applied chiefly to electro-static phenomena.

Electrization. In electro-therapeutics, the subjection of the human system to electric treatment. An electric tonic imparted by electro-medical baths through the nervous system.

Electro-chemistry. That branch of science which treats of the relations between electric and chemical forces in their different reactions and compounds. It deals with electroplating, electro-fusing, electrolysis, etc.

Electro-culture. The application of electricity to the cultivation of plants. The use of electricity has been found very beneficial in some forms of plant growth.

Electrocution. Capital punishment inflicted by electric current from a dynamo of high electromotive force. The current used is from 1500 to 2000 volts, and it acts to break down the tissues of the body.

Electrode. The terminals of an open electric circuit.

The terminals between which an electric arc is formed, as in the arc-light.

The terminals of the conductors of an electric circuit immersed in an electrolytic solution, such as the carbon and zinc of a battery.

Electrolier. A fixture for supporting electric lamps, similar to a chandelier for gas or candles. Combination electroliers conduct both gas and electricity.

Electrolysis. The separation of a chemical compound into its constituent parts by the action of an electric current.

Electrolyte. A body susceptible of decomposition by the electric current. It must be a fluid body and a conductor capable of diffusion as well as composite in its make-up: An elemental body such as pure water cannot be an electrolyte.

Electrolytic Decomposition. (See Decomposition, Electrolytic.)

Electrolytic Deposit. (See Deposit, Electrolytic.)

Electrolytic Resistance. (See Resistance, Electrolytic.)

Electro-magnetic Induction. (See Induction, Electro-Magnetic.)

Electro-magnetism. Magnetism created by electric current.

That branch of electrical science which treats of the magnetic relations of a field of force produced by a current.

Electro-medical Bath. A bath provided with connections and electrodes for causing a current of electricity to pass through the body of the patient.

Electrometer. An instrument used for measuring static electricity. Electrometers are different from galvanometers, since the latter depend on a current flowing through wires to create an action of the magnetic needles.

Electro-motive Force. Voltage. It may be compared to the pressure of water in hydraulic systems. The unit of electro-motive force is the volt.

Electro-motor. A term some-

times applied to a current-generator, such as a small dynamo or voltaic battery.

Electro-plating. (See Plating, Electro.)

Electropoison Fluid. An acid depolarizing solution for use in zinc-carbon couples, such as the "Grenet" and "Daniells" cells. The bichromate-of-potash and sulphuric-acid solution for battery charges is a good example.

Electroscope. An apparatus for indicating the presence of an electric charge and whether the charge is negative or positive.

Electrostatic Accumulator. Two conducting surfaces, separated by a dielectric and arranged for the opposite charging of the two surfaces. A faradic or static machine for accumulating frictional electricity is an example.

Electrostatics. That division of electric science which treats of the phenomena of the electric charge, or of electricity in repose, as contrasted with electro-dynamics or electricity in motion.

Electrotype. The reproduction of a form of type or engraving by the copper electro-plating process. The original is coated with plumbago and a wax impression taken of it. The face of the negative is made conductive with plumbago or tin dust, then suspended in a copper bath and connected with the current. A film of copper will be deposited on the face of the wax impression.

Element, Chemical. Original forms of matter that cannot be separated into simple constituents by any known process. There are about seventy in all, but as science advances the list is constantly being revised. New elements are discovered and known ones are being resolved into simpler forms.

Elements of Battery Cell. (See Battery Cell, Elements of.)

Emergency Switch. An auxiliary switch used as a controller on a car to reverse the action of the motor.

E-M-F. An abbreviation for electro-motive force, or voltage.

Equalizer. A term applied to a wire or bar in electro-magnetic mechanism for equalizing the pressure over a system.

Exciter. A generator used for exciting the field-magnets of a dynamo.

Extension Call-bell. A bell connected with a telephone call-bell, and located in another part of a building so as to give a distant summons.

External Circuit. (See Circuit, External.)

F. The sign commonly employed to designate Fahrenheit. Thus, 30° F. means 30 degrees Fahrenheit, or 30 degrees above zero.

False Magnetic Poles. (See Magnetic Poles, False.)

Faradic. Induced current produced from induction-coils and faradic machines.

A series of alternating electrostatic discharges, as from a Holtz influence machine.

Faradic Coil. (See Coil, Faradic.)

Faradic Currents. (See Currents, Faradic.)

Faradic Machine. An apparatus designed to produce faradic current.

Feed. To furnish an electric current, also spoken of in connection with the mechanism that moves the carbons in arc-lamps.

Feeders, or Feed Wires. The conductors which convey electric currents at different points, as in the trolley system. The current is carried along in large cables strung on poles or laid underground, and at proper distances lines are run in to feed the trolley wire.

Field. The space in the neighborhood of a dynamo or motor, or other generator of electric current, from which the apparatus takes its electricity, both electrostatic and magnetic.

Field-magnet. (See Magnet, Field.)

Field of Force. The space in the neighborhood of an attracting or repelling mass or system. There are two kinds of fields of force—the electro-magnetic and the static—from which the respective pieces of apparatus draw their store of electricity.

Filament. A long, thin piece of solid substance. It is generally as thin as a thread and flexible enough to be bent.

The hairlike element in an incandescent lamp which, when heated by a current, glows and radiates light.

Filaments, Paper. Filaments for incandescent lamps made of carbonized paper. They were the ones originally used in electric lamps, but have been superseded by other substances easier to handle and more durable.

Flow. The volume of a current or stream escaping through a conductor, such as a wire, rod or pipe.

Fluorescence. The property of converting ether waves of one length into waves of another length. The phenomenon is utilized in the production of Geissler tubes and X-rays.

Fluoroscope. An apparatus for making examinations by means of the X-rays.

Fluoroscopic Screen. A screen overspread with fluorescent material and employed for fluoroscopic examinations in connection with the X-rays.

Foucault Currents. (See Currents, Foucault.)

Force. Any change in the condition of matter with respect to motion or rest. Force is measured by the acceleration or change of motion that it can impart to a body of a unit mass in a unit of time. For instance, ten pounds pressure of steam will be indicated on a gauge made for measuring steam. That pressure of steam, with the proper volume behind it, is capable of instantly producing a given part of a horse-power. In the same way ten volts of electro-motive force is capable of pushing a current so as to exert a certain fraction of horse-power.

Force, Electro-magnetic. The force of attraction or repulsion exerted by the electro-magnet. It is also known as electric force in the electro-magnetic system.

Fractional Distillation. The process of evaporating liquids by heat, the most volatile being the first treated. When that has been evaporated and distilled the heat is raised and the next most volatile liquid is evaporated, and so on until all are evaporated, leaving as a residue the solids that were a part of the original mass of liquid.

Friction. The effect of rubbing, or the resistance which a moving body encounters when in contact with another body.

Frictional Electricity. Electricity produced by the friction of dissimilar substances.

Frictional Electric Machine. An apparatus for the development or generation of high-tension frictional electricity.

Full Load. A complete load. The greatest load a machine or secondary battery will carry permanently. The full capacity of a motor running at its registered speed for its horse-power.

Furnace, Electric. A furnace in which the heat is produced by the electric arc. It is the hottest furnace known to man, and temperatures as high as 7500° Fahrenheit have been developed in it.

Fuse, Electric. A fuse for igniting an explosive charge by electricity. It is made by bringing the terminals or ends of wires close together, so that they will spark when a current passes through them. Or a thin piece of highly resistant wire may be imbedded in an explosive and brought to white heat

by current.

Fuse-block. An insulator having a safety-fuse made fast to it.

Fuse-box. A box containing a safety-fuse, generally of porcelain, enamelled iron, or some other non-conductor.

Fuse-links. Links composed of strips or plates of fusible metal serving the purpose of safety-fuses.

Fusing-current. A current of sufficient strength to cause the blowing or fusing of a metal.

G

Galvanic. Voltaic. Relating to current electricity or the electrochemical relations of metals.

Galvanic Taste. A salty taste in the mouth resulting from the passage of a light current from a voltaic battery, the ends of the wires being held to either side of the tongue. This has been called tasting electricity, but it is really the decomposition of saliva on the surface of the tongue, due to electrolysis or the passage of a current through a liquid.

Galvanism. The science of voltaic, or current, electricity.

Galvanizing. Coating iron with a thin layer of zinc by immersing the object in the molten metal.

Galvano-faradic. In medical electricity the shocking-coil. The application of the voltaic current, induced by a secondary current (induction-coil), to any part of the body.

Galvanometer. An instrument for measuring current strength.

A magnetic needle influenced by the passage of a current through a wire or coil located near it.

Galvanometer, Tangent. A galvanometer provided with two magnetic needles differing in length, the shorter one serving to measure tangents, the longer being used for sine measurements of current strength.

Galvanoscope. An instrument, generally of the galvanometer type, used to ascertain whether a current is flowing or not.

Generator. An apparatus for maintaining an electric current, such as a dynamo, a faradic machine, a battery, etc.

German-silver. An alloy of copper, nickel, and zinc. Used chiefly in resistance-coils, either in the form of wire or in strips of the sheet-metal.

Gold-bath. A solution of gold used for depositing that metal in the electro-plating bath.

Graphite. A form of carbon. It occurs in nature as a mineral, and also is made artificially by the

agency of electric heat.

Gravity Battery. (See Battery, Gravity.)

Grounded Circuit. (See Circuit, Grounded.)

Ground-plate. (See Plate, Ground.)

Ground-wire. The contact of a conductor, in an electric circuit, with the earth. It permits the escape of current if another ground-wire exists.

Guard Tube. A tube inserted in a wooden or brick partition to insulate wires that may pass through it. These tubes are made of porcelain, gutta-percha, compositions of a non-conducting nature, and fibre.

Gutta-percha. Caoutchouc treated with sulphur to harden it; sometimes called vulcanized rubber or vulcanite. It is a product obtained from tropical trees, and when properly treated it is a valuable insulator in electrical work, particularly in submarine cables, since it offers great resistance to the destructive agencies of the ocean's depths.

H

Hand Generator. A magneto-generator driven by hand for the generation of light currents.

Harmonic Currents. (See Currents, Harmonic.)

Harmonic Receiver. A receiver containing a vibrating reed acted on by an electro-magnet. Such a reed answers only to impulses tuned to its pitch.

Heat. One of the force agents of nature. It is recognized in its effects through expansion, fusion, evaporation, and generation of energy.

Heat, Electric. Caused by a resisting medium, such as carbon or German-silver, when too much current is forced through it. The principle of the car-warmers, electric iron, electric chafing-dish, etc.

Helix. A coil of wire. Properly a coil of wire so wound as to follow the outlines of a screw without overlapping itself.

Horse-power, Electric. Meaning the same as in mechanics. Referred to when speaking of the working capacity of a motor or the power required to drive a dynamo.

Horse-power Hour. A unit or standard of electrical work theoretically equal to that accomplished by one horse during one hour.

Horseshoe Magnet. (See Magnet, Horseshoe.)

H-P. Abbreviation for horse-power.

Hydrometer. An instrument employed to determine the amount of moisture in the atmosphere.

An instrument for determining through flotation the density or specific gravity of liquids and fluids. It consists of a weighted glass bulb or hollow metallic cylinder with a long stem on which the Baumé scale is marked. Dropping it into a liquid it floats in a vertical position, and sinks to a level consistent with the gravity of the fluid.

Hydrometer, Baumé. An apparatus for testing the gravity of fluids. The zero point corresponds to the specific gravity of water for liquids heavier than water. A gauge, valuable in testing acids and other fluids used in electrical work.

I

Igniter. A mechanical hand apparatus, in which a battery, induction-coil, and vibrator are located, and whose spark, jumping across a gap at the end of a rod, ignites or lights a gas flame, blasting-powder, or dynamite.

I-H-P. An abbreviation for indicated horse-power.

Illuminating Power. Any source of light as compared with a standard light—as, for instance, the illuminating power of an electric light reckoned in candle-power.

Illumination. A light given from any source and projected on a surface, per unit of area, directly or by reflection. It is stated in terms—as, for instance, the candle-power of a lamp. When speaking of an incandescent lamp we say it illuminates equal to four candle-power or it gives a light equal to sixteen candle-power.

Immersion, Simple. Plating, without the aid of a battery, by simply immersing the metal in a solution of metallic salt.

Impulse. The motion produced by the sudden or momentary action of a force upon a body. An electromagnetic impulse is the action produced by the electro-magnetic waves in magnetizing a mass of soft iron and attracting to it another mass of iron or steel.

An electro-motive impulse is one where the force rises so high as to produce an impulsive discharge such as that from a Leyden-jar.

Incandescence, Electric. The heating of a conductor to red or white heat by the passage of an electric current. For example, an incandescent lamp.

Incandescent Circuit. (See Circuit, Incandescent.)

Incandescent Lamp-filament. (See Filament.)

India-rubber. (See Caoutchouc and Gutta-percha.)

Indicator-card. The card used in galvanoscopes, volt and ampere meters, and other instruments. It is provided with a moving needle and is marked with a graduated scale.

Induced. Caused by induction, and not directly.

Induced Current. (See Current, Induced.)

Inductance. That capacity of a circuit which enables it to exercise induction and create lines of force.

Inductance is the ratio between the total induction through a circuit to the current producing it.

Induction, Back. A demagnetizing force produced in a dynamo armature when a lead is given to the brushes. When the brushes are so set the windings on the armature are virtually divided into two sets: one a direct magnetizing set, the other a cross-magnetizing set which exerts a demagnetizing action on the other set. The position of the brushes on a dynamo or motor is indicated by their location, and if changed back induction will be the result.

Induction-coil. (See Coil, Induction.)

Induction, Electro-magnetic. When negative and positive currents are brought towards each other against their material repulsive tendencies the result is work, or energy, and the consequent energy increases the intensity of both currents temporarily. The variations thus temporarily produced in the currents are examples of electro-magnetic induction. A current is surrounded by lines of force. The approach of two circuits—one negative, the other positive—involves a change in the lines of force about the secondary circuit. Lines of force and current are so intimately connected that a change in one compels a change in the other. Therefore, the induced current in the secondary may be attributed to the change in the field of force in which it lies. The inner and outer coils of wire about the soft iron wire composing an induction-coil are the best and simplest examples of electro-magnetic induction.

Induction, Magnetic. The magnetization of iron or other paramagnetic substances by a magnetic field. The magnetic influence of a bar excited under these conditions is shown by throwing iron filings upon it. They will adhere to both

ends (that is at the negative and positive poles) but not at the middle.

Inductor. A mass of iron in a current generator which is moved past a magnet-pole to increase the number of lines of force issuing therefrom. It is generally laminated, and is used in inductor dynamos and motors of the alternating-current type.

Influence, Electric. Electric induction or influence which may be electro-static, current, or electro-magnetic.

Influence Machine. A static electric machine worked by induction, and used to build up charges of opposite nature on two separate prime-conductors.

Installation. The entire apparatus, building, and appurtenances of a technical or manufacturing plant or power-house. An electric-light installation would mean the machinery, street-lines, lamps, etc.

Insulating Joint. Used for the purpose of insulating a gas-pipe from an electric circuit.

Insulating Varnish. A varnish composed of insulating material, such as gums, shellac, or diluted rubber. Shellac dissolved in alcohol is perhaps the best. It is easy to make and dries quickly, making an insulating surface practical for almost every ordinary use.

Insulation. The dielectric or non-conducting materials which are used to prevent the leakage of electricity. The covering for magnet wires, and overhead conduits for power lines and electric lighting.

Insulation, Oil. Any non-combustible oil may be employed as an insulator to prevent electrical leakage in induction-coils, transformers, and the like. Its principal advantage lies in its being in liquid form, permitting of easy handling. Moreover, if pierced by a spark from a coil, it at once closes again without becoming ignited. A solid insulator, if pierced, is permanently injured.

Insulator. Any insulating substance or material to prevent the escape of current. The knobs of porcelain or glass to which wires are made fast.

Insulator, Porcelain. An insulator made of porcelain and used to support a wire.

Intensity. The intensity or strength of a current is its amperage. The strength of a magnetic field, its power to attract or magnetize.

Internal Circuit. (See Circuit, Internal.)

Internal Resistance. (See Re-

sistance, Internal.)

Interrupter. A circuit-breaker. Any device which breaks or interrupts a circuit. It may be operated by hand or automatically.

The vibrator of an induction-coil. The commutators of an armature.

Isolated Plant. The system of supplying electric energy by independent generating dynamos for each house, factory, or traction line.

Isolation, Electric. A term applied to "electric sunstroke." Exposure to powerful arc-light produces effects resembling those of sunstroke.

J

Joint. The point where two or more electric conductors join.

Joint Resistance. The united resistance offered by a number of resistances connected in parallel.

Jumper. A short circuit-shunt employed temporarily around an apparatus, lamp, or motor to cut out the current.

Jump-spark. A disruptive spark excited between two conducting surfaces in distinction from a spark excited by a rubbing contact.

K

Kaolin. A form of earth or product of decomposed feldspar composed of silica and alumina. It is serviceable in insulating compounds.

Kathode. The terminal of an electric circuit whence an electrolyzing current passes from a solution. It is the terminal connected to the zinc pole of a battery or the article on which the electro-deposit is made.

Key. The arm of a telegraphic sounder by which the circuit is made and broken. A pivoted lever with a finger-piece which, when depressed, makes contact between a point and a stationary contact on the base.

Keyboard. A board, or table, on which keys or switches are mounted. A switchboard.

Kilowatt. A compound unit; one thousand watts; an electric-current measure. Abbreviation, K-W.

Kilowatt Hour. The result in work equal to the expenditure or exertion of one kilowatt in one hour.

Kinetoscope. A photographic instrument invented by Edison for obtaining the effect of a panorama or moving objects by the display of pictures in rapid succession—in familiar parlance, "moving pictures."

Knife Switch. A switch with a narrow and deep, movable blade, or bar of copper or brass, which re-

sembles the blade of a knife. It is forced between two spring-clamps attached to one terminal so as to make perfect contact.

L

Laminated. Made up of thin plates, as an armature-core.

Laminated Core. (See Core, Laminated.)

Lamp-Arc. A lamp in which the light is produced by a voltaic arc. Carbon electrodes are used, and a special mechanism operates and regulates the space between the carbons so that a perfect arc may be maintained.

Lamp, Incandescent. A lamp in which the light is produced through heating a filament to whiteness by the electric current. It consists of a glass bulb from which the air is exhausted and sealed, after the filament is enclosed. The ends of the filament are attached to platinum wires, which in turn are made fast to the contact-plates at the head of the lamp, so as to connect with the current.

Lamp-socket. A receptacle for an incandescent lamp. It is generally made of brass and provided with a key-switch to turn the current on and off.

Latent Electricity. (See Electricity, Latent.)

Lead. (Not the metal.) An insulated conductor which leads to and from a source of power; an insulated conductor to and from a telegraph or telephone instrument; a circuit, a battery, or a station. Not a part of the line circuit.

That part of an electric light or power circuit which leads from the main to the lamps or motors.

Leading-in Wires. The wires which lead into a building from an aerial circuit.

The wires which lead in and out from a lamp, battery, or instrument.

Leak. An escape of electrical energy through leakage. This is more liable to occur in bare than in insulated wires. The escape of current from bare trolley wires is much greater than that from the insulated conductors, particularly in damp or rainy weather.

Leclanché Battery. (See Battery, Leclanché.)

Leyden-jar. A type of static condenser. Its usual form is a glass jar. Tin-foil is pasted about its inner and outer surfaces covering about half the wall. The balance of the glass is painted with shellac or insulating varnish. The mouth is closed with a cork stopper, and

through its centre a brass rod is passed which, by a short chain, is connected with the interior coating of the jar. The top of the rod is provided with a brass knob or ball, and from this last the spark is drawn.

Lightning. The electro-static discharge of clouds floating in the atmosphere. It is the highest form of frictional electricity, uncontrollable and very dangerous, since the strength of a single flash may run into hundreds of thousands of volts.

Lightning-arrester. An apparatus for use with electric lines to carry off to earth any lightning discharges that such lines may pick up; or it may be a form of fuse which burns out before the current can do any harm to the electrical mechanism.

Line-insulator. An insulator serving to support an aerial line.

Lineman. A workman whose business is the practical part of electrical construction in lines and conducting circuits.

Link-fuse. A plate of fusible metal in the shape of a link. It is used as a safety-fuse in connection with copper terminals.

Liquefaction, Electric. The conversion of a solid into a liquid by the sole agency of electricity in its heat action upon the solid.

Liquid Resistance. (See Resistance, Liquid.)

Lithanode. A block of compressed lead binoxide, with platinum connections, for use in a storage battery.

Litharge. Yellow-lead. A chemical form of metallic lead.

Load. In a dynamo, the amperes of current delivered by it under given conditions of speed, etc.

Local Action. In a battery, the loss of current due to impurities in the zinc. The currents may circulate in exceedingly minute circles, but they waste zinc and chemicals and contribute nothing to the efficiency of the battery.

In a dynamo, the loss of energy through the formation of eddy currents in its core or armature, in the pole pieces, or in other conducting bodies.

Lodestone. The scientific name is magnetite. Some samples possess polarity and attract iron; these are called lodestones.

Loop. A portion of a circuit introduced in series into another circuit.

Low Frequency. A frequency (in current vibrations) of comparatively few alternations per second.

Low Potential Current. (See Current, Low Potential.)

Luminescence. The power or properties some bodies have of giving out light when their molecular mass is excited. For example, phosphorus and radium.

Luminous Heat. The radiation of heat by electric current, which at the same time produces light. For example, the filament in an incandescent lamp.

Luminous Jar. A Leyden-jar whose coatings are of lozenge-shaped pieces of tin-foil between which are very short spaces. When discharged, sparks appear all over the surface where the small plates of metal nearly join.

M

Magnet. A substance or metal having the power to attract iron and steel.

Magnet-bar. A magnet in the shape of a straight bar. (See Bar-magnet.)

Magnet-coil. A coil of insulated wire enclosing a core of soft iron through which a current of electricity is passed to magnetize the iron.

Magnet-core. An iron bar or mass of iron around which insulated wire is wound in order to create an electro-magnet.

Magnet, Electric. A magnet consisting of a bar of iron, a bundle of iron wires, or an iron tube, around which a coil of insulated wire is wound. When a current is passing through the coil its influence magnetizes the iron core, but directly the current ceases the magnetism disappears.

Magnet, Field. The electro or permanent magnet in a dynamo or motor, used to produce the area of electric energy.

Magnet, Horseshoe. A magnet of U shape with the poles or ends brought closer together than the other parts of the limbs. A soft iron bar is placed across the poles when not in use, as this serves to conserve the magnetism.

Magnet, Permanent. A term applied to a hard steel magnet possessing high retentivity, or the power to hold its magnetism indefinitely.

Magnet, Regulator. An electro-magnet whose armature moves in such a manner as to automatically shift the commutator-brushes, on a motor or dynamo, to a position which insures the preservation of both brushes and commutator-bars, and also produces a constant current.

Magnet, Simple. A magnet made of one piece of metal.

Magnetic Adherence. The tendency of a mass of iron to adhere to the poles of a magnet.

Magnetic Attraction and Repulsion. The attraction of a magnet for iron, steel, nickel, and cobalt; also of unlike poles of magnets for each other. The like poles repel.

Magnetic Circuit-breakers. An automatic switch, or breaker, whose action is excited and controlled by an electro-magnet.

Magnetic Concentration of Ores. The separation of iron and steel from their gangue by magnetic attraction. It is applicable only when either the ore or the gangue is susceptible to the magnet.

Magnetic Control. The control of a magnetic needle, magnet, index, armature, or other iron indicator in a galvanometer, ammeter, or voltmeter by a magnetic field.

Magnetic Dip. The inclination from the horizontal position of a magnetic needle that is free to move in a vertical plane.

Magnetic Field, Rotary. A magnetic field resulting from a rotary current.

Magnetic Field, Shifting. A magnetic field which rotates. Its lines of magnetic force vary, therefore, in position.

Magnetic Field, Uniform. A field of uniform strength in all portions, such as the magnetic field of the earth.

Magnetic Force. The power of attraction and repulsion exercised by a magnet; the force of attraction and repulsion which a magnet exercises, and which, in its ultimate essence, is unknown to science.

Magnetic Induction. (See Induction, Magnetic.)

Magnetic Needle. A magnet having a cup or small depression at its centre, and poised on a sharp pin of brass, so as to be free to rotate. Its N pole points to the north, and its S pole to the south. A compass needle.

Magnetic Poles. The terrestrial points towards which the north or south poles of the magnetic needle are attracted. There are two poles: the arctic, or negative, which attracts the positive or N pole of the magnetic needle; and the antarctic, or positive, which attracts the S pole of the needle.

Magnetic Poles, False. It has been established that there are other poles on the earth that attract the magnetic needle when the latter is brought into their vicinity. These are called false poles, and are probably caused by large deposits of iron lying close to the surface of the

earth.

Magnetic Separator. An apparatus for separating magnetic substances from mixtures. It is used chiefly in separating iron ore from earth and rock. The mineral falls on an iron cylinder, or drum, magnetized by coils, and adheres there, while the earth or crushed rock drops below. The particles of iron are afterwards removed by a scraper. The machine is also used in separating iron filings and chips from brass, copper, or other metals, the iron adhering to the magnet, while the brass and other chips drop underneath.

Magnetism. The phenomena of attraction exerted by one body for another. It has been commonly understood that magnetism and electricity are very closely related, for without electricity magnetism could not exist, although it has not been shown clearly that magnetism plays any part in the generation of electricity. Magnetism is the phenomenal force exerted by one body having two poles (negative and positive) for like bodies. The horseshoe magnet or a bar of magnetized steel are the simplest examples of this. If both ends of the horseshoe were positive they would not attract, but would repel. If both ends of a bar were positive they would repel; but as one is negative, or north-seeking, and the other positive, they exert lines of force which attract like bodies, such as bits of iron, nails, and needles. No energy is required to maintain magnetism in a tempered steel object, such as the wiring about a soft iron core when it has been magnetized, but electric current must flow about the soft iron core in order to render it a magnet. So soon as the current ceases to flow the magnetism ceases and the soft iron fails to attract.

Magnetism, Uniform. Magnetism that is uniform throughout a mass of magnetic steel, or a core that is electro-magnetic.

Magnetize. To impart magnetic property to a substance capable of receiving it.

Magnetizing-coil. (See Coil, Magnetizing.)

Magneto Call-bell. A call-bell used principally in telephone systems, and operated by a current from a magneto-electric generator. The current is excited by turning the handle at the side of the telephone-box before removing the receiver from the hook.

Magneto-generator. A current-generator composed of a permanent magnet and a revolving armature

which is rotated between the poles of the permanent magnet.

Magnet Wire. Insulated wire used for coils. Cotton or silk covered wire is the most serviceable for winding magnets.

Main Circuit. (See Circuit, Main.)

Main Feeder. The main wire in a district to which all the feeder wires are attached.

Main Switch. The switch connected to the main wire of a line, or the main-switch controlling a number of auxiliary switches.

Mains, Electric. The large conductors in a system of electric light or power distribution.

Make and Break, Automatic. An apparatus which enables the armature of a magnet to make and break its circuit automatically.

Make-and-break Current. (See Current, Make-and-break.)

Mercurial Air-pump. An air-pump operated by mercury to obtain a high vacuum, and used extensively for exhausting incandescent-lamp bulbs.

Mercury Tube. A glass tube sealed and containing mercury. It is so arranged as to give out fluorescent light when shaken or agitated by an electric current. For example, the Geissler tubes, the Cooper-Hewitt light, Crook's tubes, etc.

Metallic Arc. An arc which forms between metallic electrodes.

Metallic Circuit. (See Circuit, Metallic.)

Metallic Conductor. A conductor composed of a metal.

Metallic Filament. A metal wire used in an incandescent lamp—the filament.

Metallic Resistance. (See Resistance, Metallic.)

Metallurgy. The art of working metals. Electro-metallurgy applies to the processes wherein electricity plays the most important part.

Mica. A natural mineral of sheet form and translucent, used extensively as an insulator in electrical equipment and mechanism.

Mica, Moulded. A composition composed of ground mica and shellac as a binder. When heated and pressed into various shapes and forms, it is a valuable insulator, and is employed for hooks, locks, tubes, sockets, and the like.

Micanite. An insulating material made by cementing laminations of pure mica together and cementing them with shellac or other suitable non-conducting adhesives.

Molecular Adhesion. The attraction of similar molecules for each other.

Molecular Attraction. The at-

traction of molecules, or physical affinity.

Molecular Resistance. The resistance which a mass or electrolyte offers when contained in an insulated vessel and a current of electricity is passed through it.

Molecule. One of the invisible particles supposed to constitute matter of every kind; the smallest particle of matter that can exist independently. It is made up of atoms, but an atom cannot exist alone.

Morse Receiver. The receiving instrument once universally used in the Morse system of telegraphy, but now superseded by the sounder.

Morse Recorder. An apparatus which automatically records on a ribbon of paper the dots and dashes of the Morse telegraph alphabet.

Morse Sounder. An electro-magnetic instrument designed to make a sharp, clicking sound when its armature lever is drawn down by the attraction of the magnets.

Morse System. A telegraphic system invented by Prof. S. F. B. Morse, in which, by means of alternating makes and breaks of varying duration, the dots and dashes of the Morse alphabet are reproduced and received at a distance through the agency of wires and the electro-magnetic sounder.

Motor, Electric. A machine or apparatus for converting electric energy into mechanical kinetic energy or power. The electrical energy is usually generated by a dynamo, and distributed on conductors to motors located at various points.

Electric motors are of two types—the A-C., or alternating current, and the D-C., or direct current.

Motor-car, Electric. A self-propelling car driven by stored electricity.

Motor-dynamo. A motor driven by a dynamo whose armature is firmly attached or connected to that of the dynamo. It is used for modifying a current. If the dynamo generates an alternating current of high potential, the motor converts it into a direct current of lower voltage but increased amperage.

Motor-transformer. A transformer which is operated by a motor.

A dynamo-electric machine provided with two armature windings, one serving to receive current, as a motor, the other to deliver current, as a generator, to a secondary circuit.

N

N. An abbreviation for the north-seeking pole in a magnet.

Natural Magnet. A loadstone.

Needle. A term applied to a bar-magnet poised horizontally upon a vertical point.

A magnetic needle, or the magnet in a mariner's compass.

Negative. Opposed to positive.

Negative Electricity. The kind of electricity with which a piece of amber is charged by friction with flannel.

In a galvanic battery or cell the surface of the zinc is charged with negative electricity. Negative electricity, according to the theory of some scientists, really means a deficiency of electricity.

Negative Electrode. The same as Negative Element.

Negative Element. The plate not dissolved by the solution in a voltaic cell; the one which is positively charged.

The carbon, platinum, or copper plate or pole in a battery.

Negative Feeder. The conductor which connects the negative mains with the negative poles of a generator.

Negative Plate. (See Plate, Negative.)

Negative Pole. (See Pole, Negative.)

Neutral Feeder. The same as Neutral Wire.

Neutral Wire. The central wire in a three-wire system.

Nickel-bath. A bath for the electro-deposition of nickel.

Non-arcing Fuse. A fuse-wire which is enclosed in a tube packed with asbestos or silk, and which does not produce an arc when it fuses or blows out. It is practically noiseless, save for a slight hissing sound, accompanied by a light puff of smoke, which escapes from a vent-hole in the side of the tube.

Non-conductor. A material or substance offering very high resistance to the passage of the electric current.

Non-magnetic Steel. Alloys of iron incapable of being magnetized. They are composed of iron and manganese, nickel, steel, etc.

Normal. Regular. The average value of observed quantities. Normal current is a regular current without variations.

The force of a current at which a system is intended to work.

Normal Voltage. The same as Normal Current.

North Pole. The north-seeking pole of a magnet.

The pole of a magnet which tends to point to the north, and whence lines of force are assumed to issue

on their course to the other pole of the magnet.

O

O. An abbreviation for Ohm.

Oersted's Discovery. Oersted discovered, in 1820, that a magnetic needle tended to place itself at right angles to a current of electricity. This fundamental principle is the basis of the galvanometer, the dynamo, and the motor.

Ohm. The practical unit of resistance. A legal ohm is the resistance of a column of mercury one square millimetre in cross-sectional area and 106.24 centimetres in length.

Ohm, True. The true ohm is the resistance of a column of mercury 106.24 centimetres long and one square millimetre in cross-sectional area. An ohm may be measured by a No. 30 copper wire nine feet and nine inches long. If larger size wire is used the piece must be proportionately longer, since the resistance is less.

Ohmic Resistance. True resistance as distinguished from spurious resistance, or counter electro-motive force. (See also Resistance, Ohmic.)

Ohm's Law. The basic law which expresses the relations between current, electro-motive force, and resistance in active circuits. It is formulated as follows:

1. The current strength is equal to the electro-motive force divided by the resistance.

2. The electro-motive force is equal to the current strength multiplied by the resistance.

3. The resistance is equal to the electro-motive force divided by the current strength.

O. K. A telegraphic signal meaning yes, or all right. It is supposed to be a misspelled form of all correct, "Oll Kerrekt."

Okonite. A form of insulation for wires and conductors; a trade name applied to insulations, and protected by copyright.

Open Arc. A voltaic arc not enclosed.

Open Circuit. (See Circuit, Open.)

Oscillating Current. (See Current, Oscillating.)

Outlet. That part of an electric light fixture out of which the wires are led for attachment to incandescent light sockets.

Outside Wiring. The wiring for an electric circuit which is located outside a building or other structure.

Overhead Feeders. The same as overhead conductors.

Overhead Trolley. The system in which the current for the propulsion of trolley-cars is taken from overhead feeders or wires.

Overhead Trolley-wire. A naked, hard copper wire drawn at high tension, and suspended over or at the side of a car-track, and from which the trolley-wheel takes its current.

Overload. In an electric motor, an excess of mechanical load prevents economical working, causing the armature to revolve slowly and the wiring to heat. In this case heating implies waste of energy.

Overload Switch. A switch which operates automatically to open a circuit in line with a motor, and so save the motor from overheating or burning in the event of an overload.

P

Paper Cable. A cable insulated with waxed or paraffined paper.

Paraffine. A residuum of petroleum oil, valuable as an insulating medium in electrical work.

A hydro-carbon composition of the highest resistance known. It is extensively used in condensers and other electrical apparatus as a dielectric and insulator.

Parallel Distribution. A distributing system for electricity wherein the receptive contrivances are adjusted between every two of a number of parallel conductors running to the limits of the system. When two or more conductors connect two mains of comparatively large size and low resistance, they are said to be in parallel or in multiple. This order is easily pictured by imagining the mains to be the sides of a ladder and the conductors the rungs. In the latter the lamps are placed. It follows that the current flows from one main to the other through the conductors and lamps.

Paramagnetic. Substances which have magnetic properties, or those which are attracted by magnetic bodies. A paramagnetic substance has high multiplying power for lines of force, therefore a bar of iron which is a paramagnetic substance of the highest quality becomes magnetic when placed within a circle of electric lines of force. The first example of paramagnetic substance brought to the attention of man was the lodestone, from which the ancient mariners fashioned their crude compass needles.

P-C. An abbreviation for porous cup.

Pear Push. A push-button en-

closed in a handle having the shape of a pear. It is generally attached to the end of a flexible wire cord.

Periodic Current. (See Current, Periodic.)

Permanency, Electric. The power of conductors to retain their conductivity unaffected by the lapse of time.

Permanent Magnet. (See Magnet, Permanent.)

Phase. One complete oscillation. The interval elapsing from the time a particle moves through the middle point of its course to the instant when the phase is to be stated.

Simple harmonic motion. Oscillation.

'Phone. An abbreviation for the word Telephone.

Phonograph. An apparatus for reproducing sound. It is vibratory and not electric in its action, except that the mechanism may be driven by electricity. It consists of a rotating cylinder of a waxlike material and a glass diaphragm carrying a needle-point that lightly touches the surface of the waxen cylinder. If the diaphragm is agitated the needle vibrates, making indentations in the surface of the wax. If the needle is set back and the cylinder rotated so as to carry the point over the indentations, the sound is given back through the vibration of the diaphragm.

Pickle. An acid solution used to cleanse metallic surfaces preparatory to electro-plating.

Pilot Wires. Wires brought from distant parts of electric light and power mains, and leading to voltmeters at a central station. Through their agency the potential energy of every part of the system may be measured.

Pith-balls. Balls made from the pith of light wood, such as elder. They are used in the construction of electroscopes and for other experiments in static electricity.

Plant. The apparatus for generating electric current, including engines, boilers, dynamos, mains, and subsidiary apparatus.

Plate, Condenser. In a static apparatus, the condenser having a flat piece of glass for a dielectric. It is mounted on an axle so that it may be revolved.

Plate, Ground. In a lightning-arrester, the plate connected to the earth or ground wire.

Plate, Negative. In a voltaic battery, the plate which is unattached by the fluid. It is made of carbon, platinum, or copper.

Plate, Positive. (See Positive Plate.)

Plating-bath. A vessel of solution for the deposition of metal by electrolysis. Used in electro-plating.

Plating, Electro. The process of depositing metal on surfaces of metals or other substances by the aid of an electrolyte and the electric current.

Platinum Fuse. A slender wire of platinum roused to incandescence by current, and used to explode a charge of powder or other combustible substance.

Plug. A piece of metal, with a handle, used to make electric connections by being inserted between two slightly separated plates or blocks of metal.

A wedge of metal, slightly tapered, and used to thrust between two conductors to close or complete a circuit.

Plumbago. Soft, lustrous graphite a native; form of carbon sometimes chemically purified. It is used chiefly in electrotyping for dusting the wax moulds to make the surface an electric conductor.

Plunge-battery. (See Battery, Plunge.)

Polar. Pertaining to one of the poles of a magnet.

Polarity. The disposition in a body to place its axis in a particular direction when influenced by magnetism. For example, the attraction and repulsion at the opposite ends of a magnet. The N and S seeking poles of a compass needle is the simplest example.

Polarity, Electric. The disposition in a paramagnetic body to be influenced by electric waves and lines of force. The otherwise non-magnetic body or mass becomes magnetic to attract or repulse when influenced by electricity, but ceases to retain the phenomena after the electric influence is removed. A piece of soft iron wire, a nail, or a short rod of iron will become electropolarized when a current of electricity is sent through a coil of insulated wire so wound that one end will be N the other S. So soon as the circuit is broken the polarity ceases.

Polarization. The depriving of a voltaic cell of its proper electromotive force. This may be brought about through the solution becoming spent, or in the event of the acid being saturated with zinc, and so failing to act on the metallic zinc.

Counter electro-motive force due to the accumulation of hydrogen on the negative plate.

Polarizing-current. (See Current, Polarizing.)

Polar Surface. The surface of a magnetic substance through which the magnetic flux passes in or out.

Pole-changer. An automatic, oscillating switch or contact-breaker which reverses the direction of the current.

Pole, Negative. The S pole in a magnet or compass needle.

Pole, Positive. (See Positive Pole.)

Pole-switch, Single. A switch designed to open or close one lead only.

Poles. The terminals of an open electric circuit at which there necessarily exists a potential difference.

The terminals of an open magnetic circuit, or the ends of a magnetized mass of iron.

Porcelain. A fine variety of earthenware, valuable for insulators and insulating purposes.

Porosity. The state or property of having small interstices or holes. The opposite of density.

Porous Cup or Cell. A cup or cell made of pipe-clay or of unglazed earthenware through which a current of electricity can pass when wet or in a liquid. Porous cups are used in cells and batteries to keep two liquids apart, and yet permit electrolysis and electrolytic conduction.

Positive Currents. Currents which deflect the needle to the left.

Positive Electricity. The current that flows from the active element, the zinc in a battery, to the carbon. The negative electricity flows from the carbon to the zinc.

Positive Electrode. The electrode which is connected with the positive pole of a source of electric energy.

Positive Feeders. The lead or wire in a set of feeders which is connected to the positive terminal of the generator.

Positive Plate. In a voltaic cell, the plate which is acted upon and corroded. The current from the positive plate is negative electricity.

Positive Pole. The N pole in a magnet or magnetic needle. So called because it seeks the north or negative pole of the earth.

Positive Wire, or Conductor. The wire, or conductor, connected with the positive pole of any apparatus which produces electro-motive force.

Potential, Electric. The power to perform electric work.

Potential Energy. Capacity for doing work. Potential energy when liberated becomes actual energy for the performance of work.

Power-generator. Any source from which power is generated.

Power-house. A station in which

the plant of an electric power system is operated and the current distributed to local or long-distance points. Power-houses are either primary or secondary stations. In the primary station the current is generated directly by the aid of mechanical power, either the steam-engine or the steam-turbine. The secondary station, or sub-station, is located at a distance from the main power-house, and has no mechanical means of generating current. The current, usually of high alternating voltage, is supplied to the sub-station from the main power-house; and by means of transformers and converters, the high-voltage current is transformed into one of lower E-M-F and higher amperage, for distribution over local lines.

Power-unit. The unit of electric power is the volt-ampere or watt.

Pressure, Electric. Electro-motive force or voltage.

Primary. A term used to designate the induction-coil in an induction-apparatus or transformer. It is an abbreviation for primary coil.

Primary Battery. (See Battery, Primary.)

Prime Conductor. (See Conductor, Prime.)

Push-button. A switch for closing a circuit by means of pressure applied to a button. The button is provided with a spring, so that when pushed in and released it flies back, reopening the circuit.

Pyrogravure. A process of engraving by the use of platinum points heated to redness by the electric current.

Q

Q. Abbreviation or symbol for electric quantity.

Quadrant. The quarter of a circle or of its circumference.

Quadruple Circuit. (See Circuit, Quadruple.)

Quantity. The term is applied to express arrangements of electrical connections for giving the largest possible amount of current.

Quantity, Electro-magnetic. The electro-magnetic current measured by its intensity for a second of time.

Quick-break. A break effected in an electric current by the employment of a quick-break switch.

Quickening. The amalgamating of the surface of a metallic object before electro-plating it with silver. This secures better adhesion of the deposit, and is done by dipping the article into a solution of mercurial salts—one part of mercuric nitrate to one hundred parts of water.

R

Radiant Energy. Energy existing in the luminiferous ether and exercised in wave transmission, creating light or sound. Radium possesses the highest form of radiant energy.

Radiate. To emit or send out in direct lines from a point or points, as radiating heat, light, or sound. The radiations are sent out in all directions from a central point, just as a stone thrown in a pond of still water will radiate waves or ripples from the central point.

Radiation. The travelling or motion of ether waves through space.

Radiator, Electric. A series of plates or wire-coils heated by current. They radiate heat and so warm the surrounding air.

Radiograph. A photographic picture taken by the X-ray process.

Receiver. In telephony or telegraphy, an instrument for receiving the message as distinguished from the instrument sending or transmitting the message.

The telephone piece held to the ear is the receiver.

Receiving End. The end of a line where the operative currents are received, as opposed to the end at which they are transmitted.

Receptacle. A device for the installation of an attachment or extension plug. Used in connection with electric-lighting circuits.

Recoil Kick. Reaction resulting from a disruptive discharge.

Recorder. In telegraphy, the receiving apparatus for recording the dot-and-dash signals on a strip or tape of paper.

Reduction. The influence exerted without apparent communication by a magnetic field or a charged mass upon neighboring bodies. The induction-coil is a simple example of this force. The current passes through the primary or inner coil about a core of soft iron, and in doing so it develops lines of force in the secondary or outer coils, although no current is flowing directly through them from a battery or dynamo.

Reduction Gear. A gear which acts to reduce a speed below that of a motor in full motion without lessening its motive force.

Refract. To break the natural course of light in an elastic medium. The rays of light, as they pass from a rare into a dense medium, are refracted.

Register, Electric. An apparatus for registering and recording the movements of employes about a building. Press-buttons are arranged throughout the building, and

when a man passes a station he presses the button, and the time is recorded by the apparatus.

Regulator Magnet. (See Magnet, Regulator.)

Relay. A telegraphic or telephonic receiving instrument which opens and closes a local circuit through movements caused by the impulses of currents received. The relay battery may be very delicate so as to work with weak currents. The function of the relay is to open and close circuits for the admission of a new current to push on the sound or vibration to a more distant point. The main battery may be of any desired power.

Relay Connection. A connection used in telegraphy, including a local battery, with a short circuit, normally open, but closed at will by a switch and sounder, or other appliance. A very weak current will work the apparatus.

Relay, Ordinary. A relay that is not polarized.

Relay, Repeating. In telegraphy, a relay for repeating the signals through a second line.

Reluctance. Magnetic resistance.

Repeater. In telegraphy, an instrument for repeating the signals through a second line. It is virtually a relay which is controlled by the sender, and which, in turn, operates the rest of the main line. It is usually located at about the middle of the total distance covered.

Repeating-station. A telegraph station located on a long line, and occupying a position at the juncture of the sections into which the line is divided. The currents received through one section are repeated into the other sections by means of a repeater.

Repulsion, Electric. The tendency which exists between two bodies charged alike to mutually repel each other.

Residual Charge. (See Charge, Residual.)

Resilience. The power to spring back to a former position. Electricity is resilient, although its elasticity cannot be measured accurately.

Resin. A solid inflammable substance or gum, and a good non-conductor in electrical work. It is the product obtained by distilling the sap of the pitch-pine. The name is also applied to the product of distilling the sap of other trees. Common resin, shellac, lac, Dragon's-blood, and other substances of a similar nature are resins. They are all dielectrics, and the source of negative frictional electricity when rubbed

with cotton, wool, flannel, silk, or fur.

Resistance. That quality of an electric conductor in virtue of which it opposes the passage of an electric current, causing the disappearance or modification of electro-motive force, and converting electric energy into heat energy.

Resistance-box. A box filled with resistance-coils connected in series and provided with a switch, so that any number of the coils may be cut out.

Resistance, Carbon. A resistance composed of carbon as a substitute for a coil of wire. Carbon rods are placed close together having an air space between them, with alternate ends connected. Piles may be built up of carbon plates, whose resistance is made to vary by changing the pressure.

Resistance-coil. A coil of wire metal or other substances having the power to resist a current of electricity.

A coil of wire used to measure an unknown resistance by virtue of its own known resistance. (See also Coil, Resistance.)

Resistance, Dielectric. (See Dielectric Resistance.)

Resistance, Electrolytic. The resistance of an electrolyte to the passage of a current decomposing it. It is almost entirely due to electrolysis, and is intensified by counter-electromotive force. When a current of a voltage so low as not to decompose an electrolyte is passed through the latter, the resistance appears very high and sometimes almost infinite. If the voltage is increased until the electrolyte is decomposed the resistance suddenly drops to a point lower than the true resistance.

Resistance, Internal. The resistance of a battery, or generator, in an electric circuit as distinguished from the resistance of the rest of the circuit.

Resistance, Liquid. A liquid of varying specific gravity used to create resistance to the passage of the electric current.

Resistance effected by the use of liquid through which a current must pass to complete a circuit.

Resistance, Metallic. The resistance of metals to the electric current.

German-silver resistance as distinguished from that of water, carbon, or other substances.

Resistance, Ohmic. True resistance measured in ohms as distinguished from counter electro-motive force. (See also Ohmic Resistance.)

Resistance, Spurious. The coun-

ter-electro-motive force. In its effect of opposing a current and in resisting its formation it differs from true resistance. True resistance diminishes current strength, absorbs energy, and develops heat. Spurious resistance opposes and diminishes a current without absorption of energy or production of heat.

Resistance, Standard. A known resistance employed to determine unknown resistances by comparison.

Resistance, True. The true resistance measured in ohms as distinguished from counter-electromotive force.

Resonator, Electric. A small, open electric circuit with ends nearly touching. When exposed to electric resonance, or to a sympathetic electric oscillating discharge, a spark passes across the gap. The spark is due to inductance in the resonator.

Retentiveness. That property which enables steel to retain its magnetism.

Return. A line or conductor which carries current back to its starting-point after it has traversed a circuit. The best definition of a return is a circuit on which no new apparatus is installed.

Return-circuit. (See Circuit, Return.)

Return-circuit, Railway. A grounded circuit used in trolley systems for ground returns through the tracks, they being joined by links or flexible wires so as to form perfect conductors. It is the negative side of the system, the positive being in the overhead or underground feed-wire or rail.

Reversibility. The principle by which any form of generator for producing a given form of energy may be reversed to absorb energy. The dynamo of the reversible type driven to generate current may be reversed and will develop power if a current is run through it.

Rheostat. An adjustable resistance. An apparatus for changing the resistance, without opening the circuit, by throwing a switch-bar across contact points.

Rod Clamp. A clamp used in the lamp rod of an arc-light to hold the carbon.

Röntgen Effects. Phenomena obtained by the use of the X or Röntgen rays.

Röntgen-ray Screen. A screen whose surface is covered with fluorescent material for the purpose of receiving and displaying the Röntgen image.

Röntgen Rays. A peculiar form of light radiation discovered by Röntgen, and which is emitted

from that portion of a high vacuum tube upon which the kathode rays fall.

Rotary Magnetic Field. (See Magnetic Field, Rotary.)

Ruhmkoff Coil. (See Coil, Ruhmkoff.)

S

Safety Fuse. A device to prevent overheating of any portion of a circuit by excessive current. It generally consists of a strip of fusible metal which, if the current attains too great strength, melts and opens the circuit.

Salt. A chemical compound containing two atoms or radicals which saturate each other. One is electro-positive, the other electro-negative.

Salts are decomposed by electrolysis, and in separating they combine to form new molecules.

Saturated. A liquid is said to be saturated when it has dissolved all the salts it will take up.

Search-light. An apparatus for producing a powerful beam of light and projecting it in any desired direction.

Secondary. A term applied to the secondary coil of a transformer or induction-coil.

Secondary Battery. (See Battery, Secondary.)

Secondary Plates. The plates of a secondary battery or storage-battery. When charged, the negative plate should be brown or deep reddish in color, and the positive slate-colored.

Self-excited. Electrified by its own current.

Self-winding Clock. A clock which automatically winds itself by electricity. It is operated by a small electro-magnetic motor which obtains its current from an outside source.

Semaphore, Electric. An apparatus for exhibiting signals. Used in the railway block system.

Series. Arranged in succession. When incandescent lamps are installed so that the current goes in and out of one lamp, and so on to the next and the succeeding ones, they are said to be arranged in series. It takes high E-M-F and current, or amperage, to operate such lamps.

Series batteries are arranged with the zinc pole of one connected to the carbon pole of the next.

Series Arc Cut-out. A device by means of which a short circuit is established past a defective lamp, thereby securing the undisturbed operation of all the other lamps in the circuit.

Series Distribution. A distribution of electricity in which the receptive devices are arranged in successive order upon one conductor, extending the entire length of the circuit.

Series Dynamo. A series-wound dynamo.

Series Incandescent Lamp. An incandescent lamp adapted for service in a series circuit.

Series Motor. A motor adapted for use in a series circuit; a motor whose field-coil winding is in series with the armature.

Series, Multiple. An arrangement of electric apparatus in which the parts are grouped in sets in parallel, and these sets are connected in series.

Series Winding. A method of winding a generator or motor in which one of the commutator brush connections is joined to the field-magnet winding. The other end of the magnet winding is connected with the outer circuit, and the second armature brush is coupled with the remaining terminal of the outer circuit.

Service Wires. Wires connected to the supply circuit or main wires, and which run into buildings to supply current for heat, light, and power.

Shellac. A resin gum, gathered from certain Asiatic trees. It is soluble in alcohol, and is used extensively in electric work as an insulator.

Shifting Magnetic Field. (See Magnetic Field, Shifting.)

Shock, Electric. The effect upon the animal system of the discharge of an electric current of high potential difference. The voltage is the main element in a shock.

Shoe. As applied to electric railways, the casting employed to bear on the third rail to take in positive current and electro-motive force.

The cast-iron plate of an electric break, which, by magnetism, adheres to another iron surface.

Short Circuit. (See Circuit, Short.)

Shunt-box. A resistance-box designed for use as a galvanometer shunt. The box contains a series of resistance-coils which can be plugged in or out as required.

Shunt-winding. A dynamo or motor is shunt-wound when the field-magnet winding is parallel with the winding of the armature.

Silver-bath. A solution of a salt of silver used in the electro-plating process.

Silver-plating. Depositing a coat-

ing of silver on a metallic surface by the acid of electro-metallurgy.

Silver-stripping Bath. An acid solution used for stripping silver from a metallic surface before replating it.

Simple Circuit. (See Circuit, Simple.)

Simple Immersion. (See Immersion, Simple.)

Simple Magnet. (See Magnet, Simple.)

Single-trolley System. A trolley system employing only one overhead conducting wire, the track and ground serving as the return-circuit.

Single-wound Wire. Wire insulated by winding or overlaying with but a single layer of material.

Sliding-condenser. (See Condenser, Sliding.)

Snap-switch. A switch so contrived as to give a quick break. A spiral spring is fastened between the handle and arm in such a manner that when the handle is drawn back the spring operates and quickly draws a knife-bar from the keeper, breaking the contact instantly and without the formation of an arc.

Socket. A receptacle for an incandescent lamp or plug.

Solenoid. A helical coil of wire of uniform diameter or cylindrical in shape. It is useful in experiments with electro-magnetism.

Solution. A fluid composed of dissolved salts; a mixture of liquids and fluids.

Sound Waves. Waves produced in an elastic medium by sonorous vibration, as in wireless telegraphy.

Sounder. In telegraphy, the instrument operated on by the key at the other end of a line. Various devices are employed to increase their resonance—as, for instance, hollow boxes. Sounders are generally placed on local circuits and are actuated by relays.

Sounder, Repeating. A telegraphic instrument which repeats a message into another circuit.

S-P. An abbreviation for single pole.

Spark-arrester. A screen of wire-netting fitted around the carbons of arc-lamps to prevent the chips or hot sparks from flying.

Spark-coil. A coil for producing a spark from a source of comparatively low electro-motive force. The induction-coil is an example.

Spark, Electric. The phenomenon observed when a disruptive charge leaves an accumulator or induction-coil and passes through an air gap.

Spark-gap. The space left be-

tween the ends of an electric resonator across which the spark springs.

Sparking. The production of sparks at the commutator, between the bars and the brushes of dynamos and motors. They are minute voltaic arcs, and should not be allowed to occur, as they cut away the metal and score the surface of the commutator.

Spark-tube. A tube used as a gauge to determine when the exhaustion of the vacuum chamber, or bulb, of an incandescent lamp is sufficiently high.

Specific Gravity. The relative weight or density of a body as compared with a standard. Water is usually taken as a standard for solids and liquids, and air for gases.

Speed-counter. An instrument which records the number of revolutions a shaft makes in a given time.

Spent Acid. Acid which has become exhausted. In a battery the acid becomes spent from combination with zinc; it also loses its depolarizing power.

Spring-contact. A spring connected to one lead of an electric circuit. It is arranged to press against another spring or contact, which it opens or closes by the introduction of a plug or wedge.

Spring-jack. An arrangement of spring-arm conductors under which plugs with wires attached can be slipped to make a new connection or to cut out certain circuits.

Spurious Resistance. (See Resistance, Spurious.)

Standard Candle. (See Candle, Standard.)

Standard Resistance. (See Resistance, Standard.)

Starting-box. A resistance or shunt box used for letting current pass gradually into motors, instead of throwing on the full current at once.

Static Electricity. Electricity generated by friction; frictional electricity, such as lightning; electricity of high electro-motive force and practically uncontrollable for commercial purposes.

Static Shock. A term used in electro-therapeutics for describing the discharge from a small condenser or Leyden-jar; also the effect produced by the action of the vibrator of the induction-coil.

Station, Central. The building or place in which the electrical apparatus is installed for the generation of current; the headquarters of telephone lines.

Steady Current. An electric current whose strength is fixed or invariable.

Stock-ticker. An instrument em-

ployed to give quotations of stocks by telegraphic record. A paper tape runs through an electrical machine which prints on it the figures and letters that stand for stocks and their values. The whole system is operated from a station located in the Stock-exchange.

Storage Accumulator. (See Accumulator, Storage.)

Storage-battery. (See Battery, Storage.)

Strength of Current. Amperage; the quantity of current in a circuit.

Stripping. The process of removing electro-plating, or thin metal coatings, from an object before it is re-electro-plated.

Stripping Liquid. The liquid in a stripping-bath used for removing metals from surfaces before replating them.

Submarine Cable. A telegraphic cable laid at the bottom of the sea or any body of water.

Submarine Search-light. An incandescent light which works under water.

Sub-station. A generating or converting plant subsidiary to a central station, and placed so as to supply current in a district situated at a distance from the main powerhouse.

Subway, Electric. An underground passageway utilized for carrying cables and wires.

Sweating. A process by which the ends of cables are brought together and soldered.

S-W-G. An abbreviation for standard wire gauge.

Switch. A device for opening and closing an electric circuit. Made in a great variety of forms, such as push-button, telegraph-key, knife switch, automatic switch, lever switch, rheostat, etc.

Switch-bell. A combined bell and switch. The bell is operated when the switch is opened or closed.

Switch-blade. The blade of a switch; a conducting strip connecting two contact-jaws.

Switch-board. A board or table to which wires are led and connected with cross-bars or other devices by which connections can be made.

Synchronize. To agree in point of time; to effect concurrence of phase in two alternating-current machines, in order to combine them electrically.

T

Table-push. A push-button connected with a call-bell and fixed on a table for convenience in using.

Tamaline. A form of cellulose

used for making the filaments of incandescent lamps. The material is cut into proper shapes, carbonized, and flashed.

Tangent Galvanometer. (See Galvanometer, Tangent.)

Tape, Insulating. Prepared tape used in covering the bared ends of wires or joints.

Tap-wires. The conductors in trolley systems that at stated intervals, take the current from the mains and supply it to the bare feed-wires.

Telegraph. A system of electric communication invented by S. F. B. Morse, in which the dot-and-dash characters are used. There are various modifications of the system—double (or duplex), multiplex, and quadruplex—by means of which a number of messages may be sent out over the same wires at one time. Communication from place to place is had over wires mounted on poles, or by underground or submarine cables.

Telegraphy, Wireless. A system of telegraphy carried on without the aid of wires, using instead the ether waves of the atmosphere to conduct the vibrations overhead, and the ground, or earth, as a return. The present limit of its working is about four thousand miles.

Telephone. An instrument and apparatus for the transmission of articulate speech by the electric current. A magnet is encased in a tube and is encircled at one end by a coil of fine, insulated wire. A diaphragm of thin iron is fixed in front of the coil and close to the end of the magnet. The ends of the coil-wires are connected with a line, at the other end of which another and similar instrument is installed. The voice causes the sending diaphragm to vibrate, and these waves are transmitted to the other instrument, where they can be heard through contra-vibrations of the receiving diaphragm.

Telephone, Long-distance. A telephone of modern construction, in which the sound-recording mechanism is so sensitive as to make the vibrations of the voice audible at long distances. It will work satisfactorily at one thousand or even fifteen hundred miles.

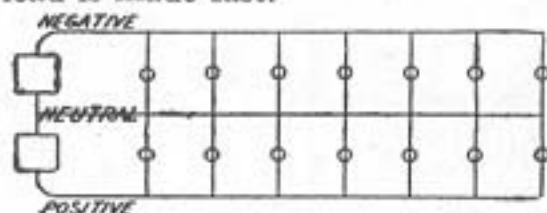
Terminal. The end of any open electric circuit, or of any electric apparatus, as the electrodes of a battery.

Thermostat, Electric. An apparatus similar in some respects to a thermometer, and used for closing an electric circuit when the latter becomes heated. It is used

in connection with automatic fire-alarms to give warning of fire. For this purpose the metal coil is arranged to close the contact at a temperature of 125° F. It usually consists of a compound strip of metal wound in the form of a spiral and fastened at one end. To this end one terminal of a circuit is connected. The expansion of the coil causes its loose end to touch a contact-point and close the circuit.

Third Rail. A railway motive system which employs a third rail instead of an overhead trolley feed-wire. The rail is laid on or under the surface of the ground and properly insulated. A shoe from the car bears on the rail and takes up the current.

Three-wire Circuit. A system invented by Edison for the distribution, from two dynamos, of current for multiple arc or constant potential service. One wire or lead starts from the positive pole of one dynamo, another from the negative pole of the other dynamo, and between the two dynamos the central or neutral lead is made fast.



Now the dynamos may generate a current of 220 volts, and send it, at this strength, through the outer wires; but if lamps are connected between either of the outer and the neutral wires, the current, passing through the lamps, will be reduced to 110 volts.

Time-ball, Electric. A ball which, by means of electricity, is made to drop from the top of a high pole, giving a visual signal for twelve o'clock or any other hour that may be designated.

Traction, Electric. The propulsion of a car or conveyance by means of electricity.

Transformer. In alternating-current systems, the induction-coil by means of which the primary current, with high initial electro-motive force, is changed into a secondary current with low initial electro-motive force.

Transmission. The conveyance of electric energy and currents from one point to another by the proper means of conduction.

Transmitter. An instrument which originates the signals which are sent through a line or circuit. The Morse key in telegraphy and the Blake transmitter in telephony are examples.

Tri-phase. Three-phase.

Trolley. A contact-wheel of bronze which rolls under the supply-wire in an overhead traction system and takes off the current necessary to run the car motors.

Trolley-wheel. The same as Trolley.

Trolley-wire. The overhead wire in a traction system which feeds the current through a trolley-wheel and pole to the motors of a car running underneath.

True Ohm. (See Ohm, True.)

True Resistance. (See Resistance, True.)

Two-wire Circuit. The single system universally used for light and power transmission of current.

U

Undulating Current. (See Current, Undulating.)

Uniform Magnetic Field. (See Magnetic Field, Uniform.)

Unipolar. Having but one pole.

Unit. The single standard of force, light, heat, magnetism, attraction, repulsion, resistance, etc.

V

Vacuum. A space empty or void of all matter; a space from which all gases have been exhausted.

Vacuum Tubes. Tubes of glass through which electric discharges are passed after the gases have been partially removed; for example, the X-ray tube of Röntgen and the Crooke tubes.

Vibrator, Electro-magnetic. The make-and-break mechanism used on induction-coils, or other similar apparatus, in which, through alternate attractions, an arm or spring is kept in motion.

Vitriol, Blue. A trade name for copper sulphate. (Bluestone.)

Vitriol, Green. A trade name for ferrous sulphate. (Copperas.)

Vitriol, White. A trade name for zinc sulphate. (Salts of zinc.)

Volt. The practical unit of electro-motive force; the volume and pressure of an electric current.

Voltage. Electric-motive force expressed in volts—as, a voltage of 100 volts.

Voltaic. A term derived from the name of the Italian scientist Volta, and used in many ways as applied to electrical current and devices. Formerly the term galvanic was commonly employed.

Voltaic Electricity. (See Electricity, Voltaic.)

Voltimeter. An instrument for

measuring the voltage of a current.

Vulcanite. Vulcanized rubber. Valuable for its insulating properties and inductive capability.

W

Watt. The practical unit of electrical activity; the rate of work or rate of energy. It is a unit of energy or of work represented by a current of one ampere urged on by one volt of electro-motive force.

The volt-ampere.

The standard of electrical energy corresponding to horse-power in mechanics.

Watt-hour. A unit of electric energy or work; one watt exerted or expended through one hour.

Waves, Electro-magnetic. Ether waves caused by electro-magnetic disturbances affecting the luminiferous ether.

Welding, Electric. Welding by the use of the electric current.

Wimshurst Electric Machine. An influence machine for producing high potential or static electricity. Thin disks of glass are mounted on insulated bearings and revolved by power. Brushes collect the frictional electricity, which is discharged into a Leyden-jar or other form of accumulator. It is of no practical use excepting in electro-therapeutics.

Wire, Flexible. A cord of fine wire strands laid together and insulated so that it may be easily bent or wrapped.

Wiring. Installing wires so as to form a circuit for the conveyance of current for light, heat, and power.

X

X-rays. A curious phenomenon involving the radiation of invisible rays of light, which have the power to travel through various opaque bodies. The rays are used in detecting foreign substances in the human body and for photographing invisible or hidden objects without disturbing their surroundings.

X-ray Lamp. A high vacuum tube lamp whose interior walls are covered with crystals of calcium or other fluorescent substances, and which, when exposed to the X-rays, give out a luminous light.

Y

Yoke. A piece of soft iron which connects the ends of two portions of a core on which wire coils are wound. It is located at the ends farthest from the poles.

The soft-iron bar placed across the ends of a horseshoe magnet retain its magnetism.

Z

Zinc-battery. A battery which decomposes zinc in an electrolyte, thereby producing a current.

Zinc Currents. Negative cur-

rents.

Zinc-plating. The employment of zinc in electro-plating.

ELECTRICITY BOOK FOR BOYS

MISCELLANEOUS APPARATUS

THE field of applied electricity is such a wide one as to preclude any exhaustive handling of the subject in a book of this size. The aim has been to acquaint the young student with the basic principles of the science, and it is his part to develop these principles along the lines indicated in the preceding pages. But there are some practical applications that may be properly grouped under the heading of this chapter. They may serve as a stimulus to the inventive faculties of the youthful experimenter, and since the pieces of apparatus now to be described are useful in themselves, the time spent in their construction will not be wasted.

A Rotary Glass-cutter

When making a circle of glass it is generally best to let a glazier cut the disk, otherwise many panes are likely to get broken before the young workman succeeds in getting out a perfect one. But with a rotary glass-cutter the task is a comparatively simple one, and the tool is really an indispensable piece of apparatus in every electrician's kit. (See Figs. 1 and 2.)

The wooden form is turned from pine or white-wood, and is three inches in diameter at the large end, or bottom, one inch in diameter at the top, and two inches high. It is covered with felt held on with glue. Directly in the middle of the top a small hole is bored one-eighth of an inch in diameter, and in this aperture an awl or marker is placed, handle up, as shown in Fig. 2. Notice that the awl is not made fast to the form, but is removable at pleasure. A hard brass strip twelve inches long, five-eighths of an inch wide, and one-eighth of an inch thick is cut at the end to receive a steel-wheel glass-cutter, as shown at the foot of Fig. 1.

A number of one-eighth-inch holes are bored along the strip, and half an inch apart, measuring from centre to centre. To cut a disk of glass the form is placed at the centre of the pane, the latter being imposed on a smooth table-top over a piece of cloth. The strip, or arm, is laid on the form, and over a small washer, so that one of the holes lines with that in the form. The awl is passed down through the strip and into the block, and the cutter is arranged in the slot at the end of the arm. Press down lightly on the handle of the awl, to keep the form from slipping; then the cutter is drawn around the glass, describing the circle, and cutting the surface of the glass, as shown by the solid line in Fig. 4. The disk must not be removed from the pane until the margin is broken away. With a straight-

edge and a cutter score the glass across the corners, as indicated by the dotted lines in Fig. 4; then tap the glass at the underside along the line and break off the corners. After the corners have been removed tap the glass again,

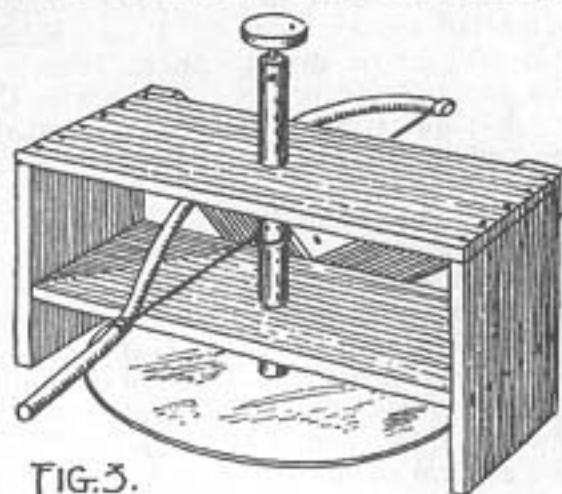


FIG. 3.

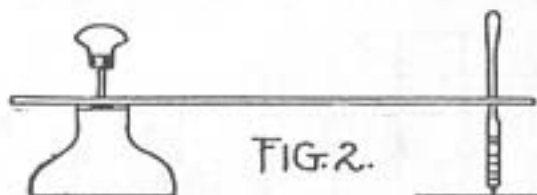


FIG. 2.



FIG. 1

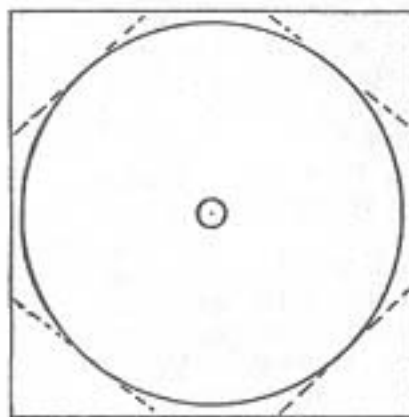


FIG. 4.



FIG. 5.



FIG. 6.

GLASS-CUTTING APPLIANCES

following the line of the circle; then break away the remaining fragments and smooth the edge.

To Smooth Glass Edges

To smooth the rough edge of glass there are several methods. The simplest way is to hold the disk or straight-edge against a fine grindstone and use plenty of water. The glass must be held edgewise, as shown in Fig. 5, and not flatwise, as shown in Fig. 6. To properly grind a disk two workmen are necessary, one to turn the stone, and the other to hold the disk by spreading the hands and grasping it at the middle on both sides (see Fig. 5). In

this manner the glass may be held securely, and slowly turned, so that an even surface will be ground. When the flat edge is smoothed, tilt the glass first to one side and then the other, and grind off the sharp edges.

Another method is to lay the glass on a table, upon a piece of felt or cloth, and allow the edge to project over the table for two or three inches. Hold the glass down with one hand to prevent its slipping; then, with a piece of corundum, or a rough whetstone and glycerine, work down the edge until it is smooth, turning the glass continually so that the edge you are working on hangs over the table. This process of grinding is somewhat tedious, but perseverance and patience will win out.

To Cut Holes in Glass

Holes may be cut in glass in several ways by an expert, but the boy who is a novice in this line should stick to slow and sure methods and take no chances. Fortunately, glass is little used in voltaic electricity, but it is indispensable in the construction of the frictional machines, Leyden-jars, and condensers, where glass is used as the dielectric, also for the covering-plates to instruments.

The simplest method is that of rotating a copper tube forward and backward over the glass, using fine emery dust for the cutting medium and oil of turpentine as a lubricant. The copper tube must be held in a rack, so that its location will not shift during the rotating or cutting motion. The rack in which the tube is held may be of any size, but to take a disk or square of glass, twenty inches across, the frame should be twenty-two inches long, ten inches wide, and twelve inches high, as shown in Fig. 3.

The side-plates are eleven inches high and ten inches wide, the top is twenty-two inches long and ten inches wide, while the under ledge is twenty and a quarter inches long by ten inches wide. This frame is put together with glue and screws. Across the back, from the corners down to the middle of the under ledge, battens or braces are made fast to prevent the frame from racking. A hole is made through the middle of the top and under ledge for the copper tube to pass through. If different-sized tubes are to be used, blocks to fit the top and under board are to be cut and bored, so that they may be held in place with screws when in use. To cut a hole in glass, place the disk or pane on a felt or cloth-covered table, and over it arrange the frame, so that the tube will rest on the spot to be drilled. Drop the copper tube down through the hole, having first spread the bottom of the tube slightly, so that it will not split the glass. Now put some emery inside the tube so that it will fall on the glass; then place a wooden plug in the top of the tube and arrange an awl, or hand-plate, so that the tube may be pressed down. Take one turn about the tube with a linen line, or gut-thong, and make the ends fast to a bow, so that it will draw the string taut but not too tight. Lubricate the foot of the tube with oil of turpentine, and draw the bow back and forth. At first the motion will cause the copper to scratch the

glass, and then cut it, until finally a perfectly drilled hole is formed. During the operation both glass and frame must be held securely, and the bow drawn evenly and without any jerking motion. Holes of different sizes may be cut with tubes of various diameters. Small holes may be cut with a highly tempered steel-drill and glycerine, the drill being held in a hand-drilling tool or in a brace.

Anti-hum Device for Metallic Lines

In overhead wires, where galvanized or hard copper wire is used, the hum due to the tension of the wires, and the wind blowing through them, causes a musical vibration which becomes most annoying at times. This can be overcome by a simple device known as an "anti-hum." It consists of a knob made of wood or rubber, through which a hole is bored, and around which a groove is cut. One end of the wire is passed through the hole and a loop formed, the loose end being wrapped about the incoming wire. The other end of the line is passed around the knob in the groove, and the end twisted about the line-wire. The knob is then an insulator and a sound-deadener at the same time. To complete the metallic circuit a loop of wire is passed under the knob, the ends of which are made fast to the line-wires, as shown at Fig. 7.

A Reel-car for Wire

It is not always convenient nor possible to carry about a heavy roll of wire when hanging a line, especially if it is No. 12 galvanized wire, of which there are from fifty to a hundred pounds in one roll. Wire should be unwound as



FIG. 7.

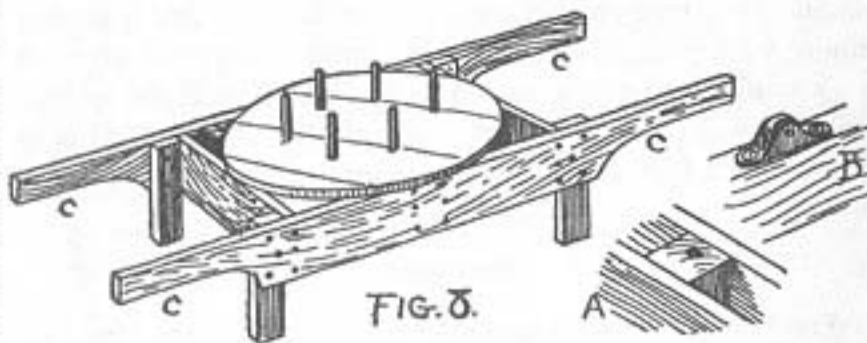


FIG. 8.

it is paid out, and not slipped off from the coil, since it is liable to kink; therefore, some portable means of transporting it should be provided. Line-wires over long distances are paid out from a reel-truck drawn by horses. For the use of the amateur electrician the reel-car shown in Fig. 8 should meet all requirements.

The reel is made from two six-inch boards, a barrel-head or a round platform of boards, four trunk-rollers, and a bolt. From a six-inch board cut two pieces five feet

long. Eighteen inches from either end cut one edge away so as to form handles, as shown at C C C C in Fig. 8, rounding the upper and under edges to take off the sharp corners. Cut four cross-pieces sixteen inches long; and from two-by-four-inch spruce joist cut four legs twelve inches long, and plane the four sides.

Nail two of the cross-pieces to the legs; then nail on the side-boards and so form the frame of the reel. Bore a half-inch hole through a piece of joist; then nail it between the remaining two cross-boards, taking care to get it in the centre, as shown at A. Arrange these pieces at the middle of the frame, making them fast with nails driven through the side-boards and into the ends of these cross-pieces. Drive some pieces of matched boards together, and with a string, a nail, and a pencil describe a circle twenty inches in diameter. With a compass-saw cut the boards on the line, and join them with four battens made fast at the under-side with nails. Do not make the battens so that they will extend out to the edge of the circle, but keep them in an inch or two, so that the under edge of the turn-table will rest on four trunk-rollers screwed fast to the top edges of the side-boards and end cross-pieces, as shown at B. A half-inch bolt is passed down through a hole made at the middle of the table, and through the block. Between the block and the underside of the table several large iron washers should be placed on the bolt, so that they will keep the table slightly above the rollers, the main weight of the table and its load of wire being held by the middle cross-brace. The object of the trunk-rollers is to relieve the side strain on the bolt, and also to prevent friction between the edge of the table and the frame, in case the tension on the wire pulls it to one side. Bore six holes in the table, on a circle of twelve inches, and drive hard-wood pegs in them, as shown in Fig. 8. When a roll of wire is lying on the table two boys can easily lift and carry the car, and as they do so the wire will pay out. Give all the wood-work a coat of dark-green paint, and oil the trunk-rollers and the wood where the bolt passes through. A pair of nuts should be placed on the lower end of the bolt and a washer under its head. These lock-nuts must be screwed on with two monkey-wrenches, forced in opposite directions, so that one nut will be driven tightly against the other. This is to prevent the turning of the table from unscrewing the nuts.

Insulators

For telegraph and telephone lines, where pole, tree, or building attachments are necessary, insulators must be used to carry the wires without loss of current. The regular glass, porcelain, or hard rubber insulators, made for pole and bracket use, are of course the best. They can be purchased at any supply-house for a few cents each, but there are other devices which will answer equally well and which will cost little or nothing.

Obtain some bottles of stout glass, the green or dark glass being the toughest; then carefully break the bottle

part away. In doing this hold the bottle by the neck, with a piece of old cloth wrapped about it, to prevent the glass chips from flying. Save all of the neck and part of the shoulder, as shown in Fig. 9, so that the wire and its anchoring loop will not slip off and fall down on the peg or cross-tree.

Hard-wood pegs cut from sticks one inch and a half square should be whittled down so that they will fit in the neck and come up to the top. The pegs should be long enough at the bottom to permit of their being fastened to the supporting poles, trees, or building. In Fig. 10 three ways of attaching insulators are shown. At A the peg is nailed to the top of a pole, or a hole is bored in the pole and the peg driven down in it. At B two sticks with peg ends are nailed to a pole in the form of a V, and across the sticks a cross-brace is made fast to prevent the sticks from spreading or dropping down. This cross-brace is made fast to both the sticks and the pole so as to form a rigid triangle. At C the usual form of cross-tree, or T brace, is shown. The pegs may be nailed to the face of the cross-plate, or holes may be bored in the top and the pegs driven down into them. If the cross-piece is more than two feet long, bracket-iron should be screwed fast to the pole and brace at both sides, as shown at C. Where a cross-plate is made fast to a pole, a lap should be cut out so that the plate can lie against a flat surface rather than on a round one (see D in Fig. 10).

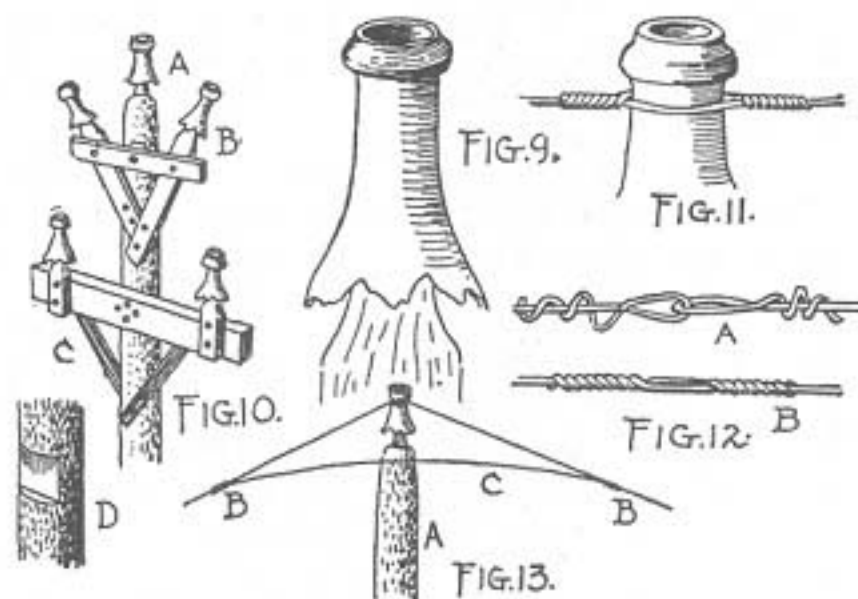
The shoulder of the bottle-necks must not rest on a cross-piece, or touch anything that would lead to the ground or to other wires. The shoulder acts as a collar, and so sheds water that in wet weather the current cannot be grounded through the rain. The underside of the collar should always be dry, and also that part of the peg protected by the collar, thereby insuring against the loss of current. The relative position of insulator and peg is shown at Fig. 9, and if the pegs are cut carefully the bottle-necks should fit them accurately.

Joints and Splices

It is essential in electrical work to have joints, splices, unions, and contacts made perfectly tight, so that the current will flow through them uninterruptedly. A poor contact or weak joint may throw a whole system out of order. For this reason all joints should be soldered wherever practicable. In line work, however, this is impossible, except where trolley-wires are joined, and these are brazed in the open air by an apparatus especially designed for the purpose. In telegraph and telephone lines perfect contact is absolutely necessary, and where attachments are made to insulators the main-line should never be turned around the insulator. The wire is brought up against the insulator, and with a U wire the main-line is tightly bound to it, as shown at Fig. 11. If it is necessary to bind the main-line more securely to the insulator, one or two turns may be taken around the insulator with the U or anchoring wire;

then with a pair of plyers a tight wrap is made.

When joining two ends of wire together, never make loops as shown in Fig. 12 A. This construction gives poor contact, for the wire loops will wear and finally break apart. Moreover, the rust that forms between the loops will often cause an open circuit and one difficult to locate. Care must be taken to make all splices secure and with per-



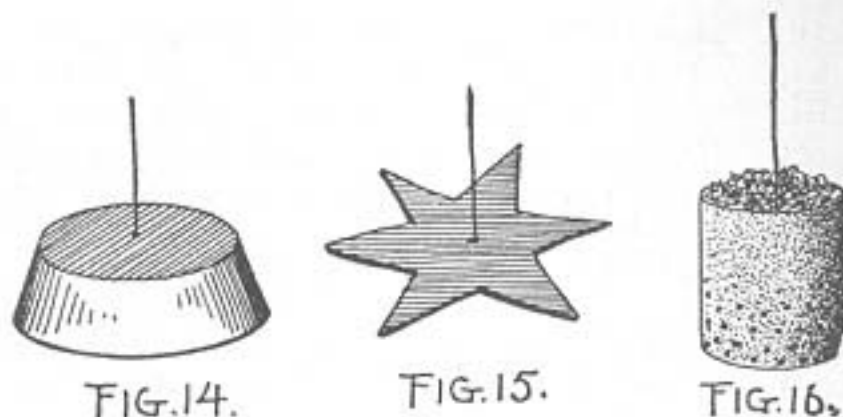
fect contact of wires, and the only manner in which this can be done is to pass the ends of wires together for three or four inches, as shown in Fig. 12 B.

Grasp one wire with a pair of plyers, and with the fingers start the coil or twist, then with another pair of plyers finish the wrapping evenly and snugly. Treat the other end in a similar manner, and as a result you will have the splice pictured in Fig. 12 B, the many wraps insuring perfect contact. This same method is to be employed for inside wires, and after the wrap is made heat the joint and touch it with soldering solution. The solder will run in between the coils and permanently unite the joint. The bare wires should then be covered with adhesive tape.

Avoid sharp turns and angles in lines, and where it is not possible to arrange them otherwise it would be well to put in a curved loop, as shown at Fig. 13. A represents a pole, B B the line, and C the quarter-circular loop let in to avoid the sharp turn about the insulator. The current will pass around the angle as well as through the loop, but a galvanometer test would show that the greater current passed through the loop and avoided the sharp turn.

"Grounds"

In the chapter on wireless telegraphy several good "grounds" were described, any one of which would be admirably adapted to telegraph or telephone circuits. In Figs. 14, 15, and 16 are illustrated three other "grounds" that can easily be made from inexpensive material. The first one, Fig. 14, is an ordinary tin pan with the wire soldered to the middle of the bottom. The wire must be soldered to be of use, as the pan would soon rust around a simple hole and make the "ground" a high-resistance one.



If the pan is buried deep enough in the earth, and bottom up, it will last for several years, or so long as the air does not get at it to induce corrosion.

The star-shaped "ground" is cut from a piece of sheet zinc, copper, or brass, and is about twelve inches in diameter. The wire is soldered to the middle of it, and it is buried four feet deep, lying flat at the bottom of the hole.

In Fig. 16 a pail or large tin can is shown with the wire passing down through the interior and finally reaching the bottom, where it is soldered fast. The can is filled with small chunks of carbon, or charcoal, and some holes are punched around the outer edge and bottom to let the water out. The can is then buried three or four feet in the ground. Use nothing but copper wire for "grounds," and it should be heavy—nothing smaller than No. 14. The wire should be well insulated down to and below the surface for a foot or two, so that perfect action will take place and a complete "ground" secured.

The Edison Roach-killer

When Edison was a boy he invented the first electrocution apparatus on record. At a certain station on the Grand Trunk Railroad, where Edison was employed as a telegraph operator, the roaches were so thick that at night they would crawl up the partition between the windows and reach the ceiling, where they would go to sleep. During the day they were apt to become dizzy, lose their footing, and drop down on the heads of the operators. This did not suit young Edison, so he devised a scheme for their destruction. While watching a piece of telegraph apparatus one day, he saw a roach try to step from a bar charged with positive electricity to one through which a negative current flowed. The insect's feet were moist and so made a connection between the two bars. As a consequence a short-circuit of high tension passed through its body and it dropped dead. This put an idea into Edison's head, and the electrocution apparatus was soon in working order. The "killer" was the most simple device one could imagine, and was composed of two long, narrow strips of heavy tin-foil pasted side by side on a smooth board, with a space of one-eighth of an inch between them, as shown at Fig. 17. To one strip a positive wire was connected, while to the other a negative or ground was made fast. High-tension current, or that from an induction-coil, was connected with

the wires, and the resulting voltage was strong enough to give one a severe shock if the fingers of one hand were placed on one plate and those of the other hand on the other plate.

This device was arranged across the window-casing in the path the roaches were accustomed to travel on their nightly trips up the side wall. It was not long after dark before roach number one sauntered up the wall, crossed the under strip, and stepped over on the upper one. But he went no farther, and he, with many of his friends and relations, were gathered up in a dust-pan the next morning and thrown into the stove.

In electricity, as in many other things, simplicity is the key-note of success; and from this little device to employ the alternating current for ridding a house of an insect nuisance sprang the grim apparatus known as the "death chair," used in the execution of first-degree criminals in the

board with copper tacks and polished as bright as possible, the finished board appearing as shown in Fig. 18.

Wires were soldered to each strip, and these in turn were connected to a high-tension current of several thousand volts. Crumbs and small pieces of meat were placed on the board inside the circles, and the trap was set in a convenient place on the floor of the laboratory.

The next morning several mice lay dead on the floor, but at some distance from the board, and this seemed a little mysterious. The following night the author worked late in the laboratory. After finishing what he had on hand, he turned down the lights and sat down and watched the trap. Presently Mr. Mouse appeared from somewhere. He sniffed the air, then approached closer to the board, sniffed again, and, evidently concluding that he was on the right trail, he climbed up the side of the board and stood on the outer strip. He placed one fore-foot on the inner strip, and, bang! up he went in the air, and landed on the floor a foot or more away. His jump into space was due to the electric action on his muscles, for the current literally tore his nervous system into shreds.

Mr. Mouse lost a great many friends and relatives that season in the same manner, and the apparatus is confidently recommended as a certain and humane agent for the destruction of all small vermin.

FORMULÆ

IN the construction of electrical apparatus there are many things, such as paint, cement, non-conducting compounds, and acid-proof substances, that are necessary in assembling the parts which make up complete working outfits. Accurate formulæ and directions for these things will save the amateur trouble and expense, since they indicate the materials which have been put to the test of time and wear by others who have had abundant experience along these lines.

The amateur will not need a large number of compounds, but such as are necessary should be of the best. Those which are described in this chapter can be relied upon to give working results.

Acid-proof Cements

One of the best acid-proof cements is made by adding shellac, dissolved in grain alcohol, to red-lead until it is at the right consistency. It can be used in liquid form or in a putty-like paste. The consistency is governed by the amount of shellac added to the red-lead. The lead should be pulverized and free from lumps. This cement can be mixed in a small tin cup or on a piece of glass, with a knife having a thin blade.

It should be used as soon as it is mixed, since it "sets" as quickly as shellac, and then dries from the outside towards the middle. In a week or two it will become dry and hard like stone.

Another cement, which will also dry as hard as a stone

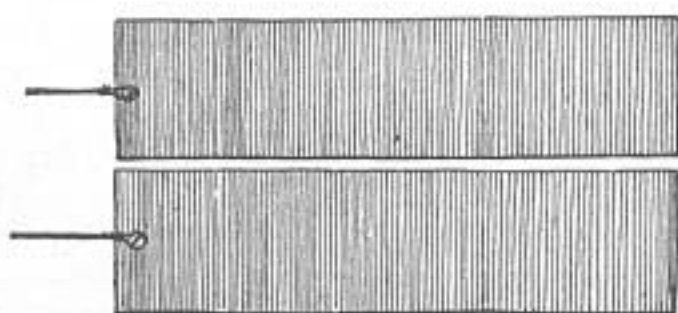


FIG. 17.

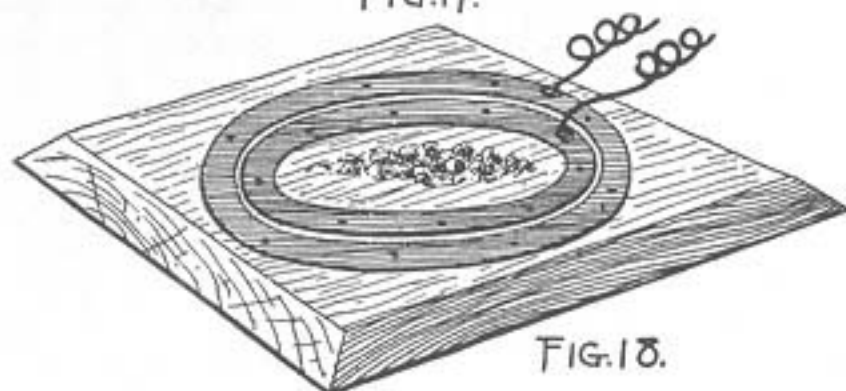


FIG. 18.

State of New York. Many people think the mechanism for electrocution is a complicated one, but it is quite as simple as the Edison roach-killer. One pole is placed at the head of the criminal and the other at the feet, the latter being bound fast so that perfect contact can be had. Then an alternating current of fifteen hundred to two thousand volts is run through the body, and death is instantaneous and void of pain.

An Electric Mouse-killer

A modification of the simple roach-killer was recently used by the author in his laboratory to get rid of some troublesome mice. A piece of board was cut twelve inches square, the edges being bevelled so that it would be an easy matter for the mice to climb up on it. An inch-wide circle of sheet brass was prepared measuring eleven inches outside diameter and nine inches inside. Another circle was cut measuring eight inches and a half outside and six inches inside diameter. Both circles were attached to the

and will hold soapstone slabs together as if they were of one solid piece, is made of litharge (yellow lead) and glycerine. The glycerine is added to the pulverized litharge to make a paste, or it can be mixed and kneaded like thin putty. It should be used very soon after mixing, as it sets rapidly.

Hard Cement

A medium hard cement is made from plaster of Paris, six parts; silix, or fine sand, two parts; dextrine, two parts (by measure). Mix with water until soft; then work with a trowel or knife.

Soft Cement

A good soft cement is made of plaster of Paris, five parts; pulverized asbestos, five parts (by weight). Add water enough to make a soft paste, and use with a trowel or knife. This is a heat-proof compound and is commonly known as asbestos cement.

Very Hard Cement

One of the hardest cements that can be made is composed of hydraulic cement (Portland or Edison), five parts; silix, or white sand, five parts (by measure). Mix with water and use like plaster with a trowel or spatula.

Care must be taken when the parts are combined to see that the cement is free from lumps. These must be broken before the silix, or sand, and water are added. Then the two parts should be mixed together at first and moistened afterwards. The proper way is to place some water at the bottom of a pan; then add the dry mixture by the handfuls, sprinkling it around so that the water can enter into it without forming lumps. Keep adding and mixing until the mass is at the right consistency to work.

All these cements are acid-proof.

Clark's Compound

For exterior insulation, where the parts are exposed to the weather, a superior compound is made up of mineral pitch, ten parts; silica, six parts; tar, one part (all parts by weight). This is called Clark's compound, after the man who invented it and used it successfully.

It is heated, thoroughly mixed, and used with a brush or spatula.

Battery Fluid

A depolarizing solution for use in zinc-carbon batteries like the Grenet is composed as follows:

Dissolve one pound of bichromate potash or soda in ten pounds of water (by weight). When it is thoroughly dissolved add two and one-half pounds of sulphuric acid, slowly pouring it into the bichromate solution and stirring it with a glass rod. The addition of the acid will heat the solution. Do not use it until it has entirely cooled.

Glass Rubbing

To rub the edges of glass, such as the disks for Wimshurst machines, obtain a piece of hard sandstone, such as is used for sharpening knives or scythes. The glass is placed on a table so that the edge extends beyond. Oil of turpentine is rubbed or dropped on the surface of the stone, and the edge of the glass is moistened with a rag soaked in the turpentine. Hold the glass down securely with one hand, and with the other grasp the stone and give it a forward and backward motion, grinding the glass along its edge and not crosswise. With care and patience a rough edge can soon be brought to a smooth one, and a soft, rounded corner substituted for the hard, angular, cutting edge that makes the glass a difficult thing to handle. Use plenty of lubricant in the form of oil of turpentine to make the work easy.

Acetic Glue

One of the best glues for glass and wood or glass and fibre is made by placing some high-grade glue (either flake or granulated) in a cup or tin and covering it with cold water. Allow it to stand several hours until the glue absorbs all the water it will and becomes soft; then pour the water off, and add glacial acetic acid to cover the glue. The proportion should be eighteen parts of glue to two of acid. Heat the mass until it is reduced to liquid, stirring it until it is thoroughly mixed. When ready for use it should be poured into a bottle and well corked to keep the air away from it.

Insulators

Apart from glass and porcelain, insulators can be made from non-conducting compounds, the best of which is molded mica. Ground mica or mica dust is mixed with thick shellac until it is in a putty-like state. It may then be forced into oiled molds of any desired shape. Hydraulic pressure is employed for almost every form of molded mica that is made for commercial purposes; but as a boy cannot employ that means to get the best results, he must use all the pressure that his hands and a flat board will give.

Another compound is made from pulverized asbestos and shellac, with a small portion of ground or pulverized mica added, in the proportion of asbestos, six parts; mica, four parts. Shellac is added to make a pasty mass, which is kneaded into a thick putty and forced into oiled molds until it sets. It is then removed and allowed to dry in the open air, and the mold used for more insulators.

Non-conductors

When working in different materials that seem adapted to electrical apparatus, it is necessary to know whether they can be used safely or not. Often a material seems to be just the thing, but if it should be a partial conductor, when a non-conductor is desired, it would be hazardous to use it. A list of non-conductors is therefore valuable to the

amateur. Some of the principal non-conductors, among the many, are as follows: glass, porcelain, slate, marble, hard stone, soapstone, concrete (dry), hard rubber, soft rubber, composition fibre, mica, asbestos, pitch, tar, shellac, cotton, silk; cotton, silk and woollen fabrics, transite (dry), electrobestus (dry), duranoid; celluloid, dry wood (well seasoned), paper, pith, leather, and oil.

While this account of formulæ and material might be extended, this is not necessary inasmuch as the formulæ and practical directions which have been given will answer all usual practical requirements.

Insulating Varnish

There are several good insulating varnishes that can be used in electrical work, the most valuable being shellac dissolved in alcohol and applied with a brush. To make good shellac, purchase the orange-colored flake shellac by the pound from a paint-store, place some of it in a wide-necked bottle, and cover it with alcohol; then cork the bottle and let it stand for a few hours. Shake the bottle occasionally until the shellac is thoroughly dissolved. It can be thinned by adding alcohol. Always keep the bottle corked, taking out only what is necessary from time to time.

Another varnish can be made by dissolving red sealing-wax in alcohol and adding a small portion of shellac. This can be applied with a soft brush, and is a good varnish. When colors are to be applied to distinguish the poles, red

is used for the positive current-poles and blue or black for the negative, if they are colored at all.

A very good black varnish is made by adding lampblack to shellac; another consists of thick asphaltum or asphaltum varnish. This is waterproof, and dries hard, yet with an elastic finish.

Battery Wax

For the upper edges of glass cells, such as the Leclanché or other open-circuit batteries, there is nothing superior to hot paraffine brushed about the upper edge to prevent the sal-ammoniac or other fluids from creeping up over the top. The paraffine can be colored with red-lead, green dust, or powders of various colors if desired, but generally the paraffine is used without color, so that it has a frosted-glass appearance when it is cool and dry.

A black wax for use in stopping the tops of dry cells and coating the tops of carbons is composed of paraffine, eight parts; pitch, one part; lampblack, one part. Heat the mixture and stir it until thoroughly mixed; then apply with a brush, or dip the parts into the warm fluid.

Another good black wax is composed of tar and pitch in equal parts. They are made into a pasty mass with turpentine heated over a stove, but not over an open flame, because the ingredients are inflammable. The compound should be like very thick molasses, and can be worked with an old table-knife.

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Haggis, a Scotch dish, called by Burns the 'great chieftain o' the puddin' race,' is usually made with the large stomach-bag of a sheep, also one of the smaller bags called the king's hood, together with the lights, the liver, and the heart. After the stomach-bags have been well cleansed, the small bag is boiled along with the pluck. A quarter of the liver is now grated down, and the heart, lights, and small bag are minced very fine along with a large onion and enough beef-suet to moisten the meal. Two small teacupfuls of oatmeal previously crisped before the fire are added, with salt, and black and Jamaica pepper. The whole is now stirred together, and put in the large bag, which, however, must not be much more than half filled; it is sewed up, and afterwards boiled for about three hours.

Hair. With the exception of the palms of the hands and the soles of the feet, the human skin is almost everywhere studded over with hairs. In few localities, however, does the hair attain any degree of thickness or length. Except on the scalp, the male cheeks, &c., the hairs are fine, short, and scanty, but more apparent in the male than the female.

An individual hair may be regarded as consisting of a root, a shaft, and a point. The root is the short, soft bulbous portion which is withdrawn from the skin when a hair is plucked from the body; the shaft is the part which projects beyond the surface of the integument; and the point is its attenuated free extremity.

The root of the hair is enclosed within a minute tubular depression in the skin which is termed the *hair-follicle*. This is the chamber in which the hair is manufactured, and it is here also that additions are made to its root so that it increases in length. The skin is composed of two layers: an outer epidermis and an inner corium. The epidermis is the cellular protective layer, and the hair and nails may be regarded as outgrowths from it. Amongst the lower animals the claws, hoofs, spines, feathers, scales, &c. all belong to the same category—all, like the hair, are appendages of the epidermal layer of the skin. The corium is fibrous and vascular, and rests directly upon the fatty subcutaneous tissue of the body. Both layers of the skin take part in the formation of the hair-follicle. Its wall, therefore, has two distinct layers entering into its formation—the inner layer being cellular and epidermic, whilst the outer layer is fibrous and continuous with the corium. When a hair is wrenched out of its socket the inner layer of the follicle adheres to the root, and is in great part withdrawn with it. It is therefore termed the *root-sheath*. In the case of the short hairs the hair-follicles do not sink beyond the skin, but in the case of the head-hairs and beard they are much deeper, and penetrate into the subcutaneous fatty tissue.

The extremity of a fresh hair-root is expanded in the form of a knob, called the *hair-bulb*. This hair-bulb is composed of cells like those of the root-sheath, and at the bottom of the follicle the two are directly continuous with each other around the circumference of the bulb. Again, at the bottom of the hair-follicle there is a little fungiform projection continuous with the corium. It is called the *hair-papilla*, and is plentifully supplied with both blood-vessels and nerves. This papilla is of the utmost importance in connection with the process of hair-growth. It is also an agent in fixing the hair in its follicle, because the lower aspect of the hair-bulb is hollowed out into a cavity, and the papilla is received into this in the same manner as a head is received into a cap.

In structure a hair may be considered as being composed of three distinct parts. Its chief bulk consists of *fibrous substance*; this is coated on the outside by a thin scaly layer, termed the *hair-cuticle*, whilst its centre is traversed by a narrow cellular thread or core, which is termed the *medulla*. The hair-cuticle is exceedingly thin, and is formed by a single layer of minute flat scales deposited upon the surface of the

hair. These scales overlap each other in an upward direction from the root to the point of the hair. The free uncovered margins of the cuticular scales therefore look upwards towards the point, and when examined under the microscope they appear on the surface of the hair in the form of wavy lines, and at the same time give to its outline a slightly toothed or serrated appearance. It is the arrangement of these scales which gives to hair its commercial value. It is due to them that the *felting* of hair is possible. But human hair is ill adapted for this purpose, because the cuticular scales are closely applied to the body of the hair. In wool, however, the scales stand well out, and the serrations are so distinct that the hairs interlock firmly the one with the other.

We have mentioned that the hair-root is attached to its follicle (1) by a continuity at the bottom of the follicle of the cells composing the hair-bulb and those forming the root-sheath, and (2) by the hair-bulb being moulded over the surface of the fungi-form hair-papilla. There is yet a third connection. The follicle is lined by delicate imbricated scales, which are directed downwards and interlock with the upwardly-directed scales which coat the hair-root.

The *fibrous substance* of the hair is composed of flattened fibres applied to each other in the longitudinal direction, and firmly united by intervening cement-substance. These fibres can be still further resolved into minute flattened elongated plates or cells, which constitute the ultimate elements of the fibrous substance. The pigment or colouring matter of the hair is distributed throughout the fibrous substance. It is partly placed within the cells which build up the fibres, and partly in the cement-substance which glues the cells together. But the colour of a hair is not entirely determined by the quantity or kind of pigment present. It is also to a certain extent determined by the presence of air which is contained in minute chinks or crannies in the fibrous substance. These air-spaces are numerous in white hairs, but are almost entirely absent in black hairs.

The *central medulla* is not present in every hair, nor, indeed, is it to be found throughout the entire length of those hairs in which it exists. Thus it is absent in the fine short hairs of the body, and also in a large proportion of the hairs of the scalp. In structure it consists of two or three rows of rectangular cells, which contain a certain amount of air.

The structure of human hair is such that it can almost always be distinguished from hair drawn from other sources. At the same time it should be noted that the hair of certain of the anthropoid apes (more especially the Chimpanzee and Gorilla) resembles it so closely, both in structure and in microscopical appearance, that the differentiation would be matter of extreme difficulty—if indeed it were possible. Waldeyer, in his *Atlas der Menschlichen und Thierischen Haare* (1884), gives a series of beautiful illustrations in which the hair of man may be compared with that of certain of the lower animals.

In connection with each hair there is a remarkable contrivance by means of which it is kept smooth, glossy, and pliant. It is furnished with two or more oil-glands, which secrete a greasy fluid. Each of these glands consists of a little sacculated



Fig. 1.
Vertical section of Skin, showing hair-follicle:
a, epidermis; b, hair;
c, hair-bulb; d, oil-glands; e, fat-cells.

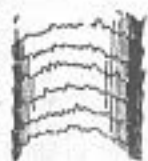


Fig. 2.
Surface of a human hair, magnified.

pouch which opens into the hair-follicle near its orifice by a short duct or channel of exit. The oily matter which is formed in the gland is discharged into the hair-follicle, and thus upon the surface of the hair.

Hairs are likewise provided with minute muscles. These consist of slender bands of contractile tissue, which cross the obtuse angle which is formed by the hair-follicle and the surface of the skin. On the one hand this little muscle is attached to the superficial part of the true skin, and on the other to the lower end of the hair-follicle. They are not under the control of the will, but cold and certain emotions, such as horror and fear, will bring them into play. In such cases the hair-muscles contract; they straighten the hair-follicles and erect the hairs. The condition known as 'goose-skin' is the result.

The hair-follicle is the laboratory in which the manufacture and continued growth of the hair is effected. At the bottom of the follicle is the little papilla upon which the hair-bulb is moulded. The blood-vessels of the papilla supply the material necessary for the growth of the hair. Additions are made to its base, and as it rises up in the follicle its upwardly-directed scaly covering sweeps before it the scales lining the follicle. The scales which are thus carried to the surface constitute a part of the scurf of the head. The rate at which the hair grows differs very much in different parts of the body, and it is also said to be affected by the age of the individual, the age of the particular hair under investigation, the season of the year, and even the hour of the day. The average growth of the beard has been computed to be $6\frac{1}{2}$ inches each year. In the growth of the head-hair the greatest discrepancies exist in the results obtained by different observers. In young females who have lost their hair by fevers it has been noticed to grow at the rate of 7 inches each year.

When the growth is good the average length of hair on the female head will be found to vary from 22 to 28 inches. Anything beyond this must be regarded as exceptional. Cases, it is true, are recorded in which it has measured from 5 to 6 feet; but these are very rare. In the 'Hair Court' of the 1862 international exhibition there was a specimen of jet-black hair measuring 74 inches. But most extraordinary instances are recorded of the power of hair-growth possessed by certain of the North American Indians. A chief of the Crow tribe is mentioned by Catlin as having hair of the almost incredible length of 10 feet 7 inches.

The duration of hair-life is limited, and sooner or later it is shed. Indeed it is stated that the hairs of an infant are completely shed within a year after birth; those on the body and limbs go first, whilst the hairs of the head and the eyelashes

follow. This change is carried on almost imperceptibly, seeing that the place of the falling hairs is taken by a second crop. The process of loss and renewal is very simple. The old hair is detached from the papilla, and soon another hair makes its appearance at the bottom of the same follicle, and grows towards its orifice. The detached hair is thus thrust out and shed. The whole process is not unlike the replacement of the milk teeth in the child by the permanent teeth. The second crop of hair which appears is perennial. An eyelash has been calculated to remain attached for 110 days. A head-hair has a longer period of life. It lives from two to four years. Before it dies provision is made for its successor, and so the process of shedding and renewal goes on continually. During its life a hair is only capable of growing a certain determinate length. The circumstance which determines this length is the amount of nutritive material which can be drawn from the blood-vessels of the papilla. Thus when a hair has attained its full length it will resume growth for a second time on being cut short. It is only when the loss exceeds the powers of renewal that a tendency to baldness results. In the case of the female head the daily loss may contain a quarter of the hairs shed of a length under 6 inches without giving rise to apprehension. Should the number of fallen short hairs exceed this proportion the hair-loss is abnormal, and baldness is likely to ensue.

As age advances the hair becomes gray. This is a natural and physiological process; but it may be

hastened by severe trouble or other causes. In many cases the premature blanching of the hair is hereditary. When the change is taking place partly-coloured hairs may be frequently found; of these it is the basal portion which is white, while the terminal part retains its colour. Brown-Séquard made some interesting experiments on his own beard whilst it was turning gray. He marked certain of the coloured hairs, and kept a constant watch on them. He states that in some cases an entire hair would turn gray in the course of a night. Two factors would seem to be at work in producing this condition of hair—viz. a loss of the power to produce pigment, and an increase of air in the shaft of the hair. Sometimes the change occurs rapidly—in the course, perhaps, of a few hours. Well-authenticated cases of this are on record. It is said that the auburn hair of Marie Antoinette turned gray in a single night. Surgeon Parry asserts that he actually saw the jet-black hair of a rebel sepoy whilst under examination and the fear of a horrible death turn gray in the course of half an hour. Baron Alphonse de Rothschild during the Commune is another instance. It is difficult to give any reasonable explanation of these sudden cases of hair-blanching.

The hair is regarded by anthropologists as being of high importance as a race character. Although there is no one special colour of hair peculiar to any one race, this character must not be disregarded. In our own country we may see every hue from the fairest flaxen to the blackest jet. Without doubt this points to a diversity of origin. Independently of colour, however, there are characters present in the hair which separate many of the races of man widely from each other. In the American Indians, Chinese, Japanese, and natives of High Asia the hair is long, straight, and harsh like a horse's mane. Amongst the negroes, Hottentots, and Papuans it is crisp and woolly. Between these extremes we may place the European, in whom the hair is wavy and flowing. The close curling of the negroes' hair has been shown by several observers to be largely due to the fact that the hair-follicles are curved. A spiral twist is thus given to the hair. It has been held that the straight harsh hair of the American Indian is circular in transverse section, that the wavy European hair is oval, and that the crisp woolly negro hair is flattened and tape-like in cross-section. There now appears to be reason to doubt this (see Waldeyer's *Atlas*).

The chief use of the hair, and particularly of the fur of various mammals which is especially developed in the winter, is to protect the body from external cold. Except on the scalp and on the throat, this cannot be considered as applying to man. What, then, are the uses of the hair on the face, and especially on the upper lip? We shall answer this question with an extract from an article 'On the Use of the Hair' in the *Lancet* for November 3, 1860: 'Mr Chadwick, who has done so much for sanitary reform, tells us that he was once very much struck by seeing some blacksmiths who wore beards, with their moustaches discoloured by a quantity of iron dust which had accumulated amongst the hairs. Turning it over in his mind, it struck him that had not the dust been so arrested by a natural respirator, it must have found its way into the lungs, where it could not have been otherwise than productive of evil consequences. He hence rightly advised that the razor should be discarded by labourers in all dusty trades—such as millers, bakers, masons, &c.; by workmen employed in grinding iron or steel; and by travellers on dusty roads. In hot, sandy countries the use of the beard is soon discovered; and travellers in Syria and Egypt find it necessary to defend their mouths against the entrance of the hot air of the desert. But not against dust alone is the facial hair a protection; it is the best barrier against cold air, biting winds, and wheezy fogs that a Northman can obtain. . . . According to Mr Chadwick, the sappers and miners of the French army, who are remarkable for the size and beauty of their beards, enjoy a special immunity against bronchial affections. In corroboration of the last-named fact we may mention another of a still more striking character. During the long-continued search for Franklin's expedition, a transport vessel, the *North Star*, was frozen up during one of the severest arctic winters on record, in Wolstenholme Sound. The crew maintained their health perfectly during all the trials to which they were exposed. On their return to England in the early summer they shaved off the hair that had been growing around the mouth and throat for the last eight or nine months, and within a week every man was on

the sick list with some form of bronchial or pulmonary disorder.

The short hairs scattered over the body may be regarded as being rudimentary. In other words, they are vestiges of a hairy covering which at one time did fulfil a protective and sheltering function. In the Ainos of Japan and the Todas of the Nilgherries these hairs are still retained in a high degree of development.

Cases occasionally occur where there is an abnormal abundance of hair of considerable length in women on parts where the hair is usually little more than down. A hairy woman, named Julia Pastrana, supposed to be a Mexican, was exhibited in London; her embalmed body was exhibited also in that city in 1862, and we extract the following remarks from a memoir on her in *The Lancet* for May 3 of that year: 'The ears, and all parts of the face except the eyes, were covered with hair of different lengths. The beard was tolerably thick, the hairs composing it being straight, black, and bristly, the part of it which grew on the sides of the chin hanging down like two plaits. . . . The upper portion of the back of the neck and the hinder surface of the ears were covered with hairs. On the shoulders and legs the hairs were as abundant as they are occasionally seen on very powerful men.' Dr Chowne described similar but less marked cases of hairy women in the *Lancet* for 1843; and in 1886 members of a Burmese family, whose bodies were almost entirely covered with hair, were first exhibited in London.

Hair-dyes. Various means have been adopted for changing the natural colour of the hair to a more favoured one, and for hiding the approaches of age, as indicated by the presence of gray hairs. These usually consist in washing the hair with a solution of some metallic salt known to have the effect of darkening its colour, such as salts of silver, mercury, lead, and bismuth. Pyrogallie acid is also employed to give a brown tint, while a solution of peroxide of hydrogen in water imparts a fine golden colour. The most perfect mode of dyeing the hair black is that of previously preparing it by a complete soaking with a solution of sulphide of potassium; the strength of this solution must depend on the depth of tint intended to be given; the stronger the solution the darker the colour will be. When thoroughly wetted, the hair is allowed to dry partially; and whilst still damp it is to be saturated with a solution of nitrate of silver, of a strength proportionate to the depth of colour desired. This makes a very permanent dye, which only requires renewing where the new growth of hair becomes conspicuous. The fashion of dyeing the hair is very ancient, and belongs as much to savage as to civilised nations; but in the case of the former vegetable dyes have been chiefly used. In China and other eastern countries the juice of the petals of *Hibiscus Trionum*, the Bladder-Ketmia, and probably other species of *Hibiscus*, is in general use.

The detection of stained hair is sometimes an object of medico-legal investigation. Lead may be detected by boiling the hair in dilute nitric acid, and then applying the tests for Lead (q.v.) to the acid solution; while the presence of silver may be shown by digesting the hair in dilute hydrochloric acid or chlorine water, when the resulting chloride of silver may be dissolved out with a solution of ammonia, and submitted to the ordinary tests for Silver (q.v.).

Halogens, or SALT-PRODUCERS (Gr. *hals*, salt'), are a well-characterised group of non-metallic elements—chlorine, bromine, iodine, and fluorine—which form with metals compounds analogous to sea-salt. For haloid salts, see SALT.

Ham, properly the hind part or angle of the knee; but usually applied to the cured thigh of the hog or sheep, more especially the first. Ham-curing, or, what is the same thing, bacon-curing, is performed in a variety of methods, each country or district having its own peculiar treatment; these, however, relate to minor points. The essential operations are as follows: The meat is first well rubbed with salt, and either left on a bench that the brine may drain away, or covered up in a close vessel; after a few days it is rubbed again, this time with a mixture of salt and saltpetre, to which sugar is sometimes added, or with a mixture of salt and sugar alone. It is then consigned to the bench or tub for at least a week longer, after which it is generally ready for drying. *Wet salting* re-

quires, on the whole, about three weeks; *dry salting*, a week longer. Mutton-hams should not be kept in pickle longer than about three weeks. Some hams are merely hung up to dry without being smoked; others, after being dried, are removed to the smoking-house, which consists of two and sometimes three stories; the fire is kindled in the lowest, and the meat is hung up in the second and third stories, to which the smoke ascends. The fire is kept up with supplies of oak or beech chips, though in some districts twigs of juniper, and in many parts of Great Britain peat, are used. Fir, larch, and such kinds of wood, on account of the unpleasant flavour they impart, are on no account to be used. The fire must be kept, night and day, in a smouldering state for three or four days, at the end of which time the ham, if not more than five or six inches deep, is perfectly smoked. As cold weather is preferable for the operation of curing, it is chiefly carried on during winter. Many of the country-people in those parts of England where wood and peat are used for fuel smoke hams by hanging them up inside large wide chimneys, a method common in Westmorland. The curing of beef and mutton hams is carried on chiefly in the north of England and Dumfriesshire in Scotland; that of pork-hams, on the other hand, is found in various countries, among the best known being those connected in commerce with the names of Belfast and Westphalia. Harris of Calne, Wiltshire, introduced an ammonia freezing-process available both summer and winter. Chicago (q.v.) is the chief centre of the enormous American industry of pork-packing.

Hand, THE. The genus *Homo*, or Man, was ranked by Cuvier in his classification of mammals as a distinct order, *Bimana*, in consequence of man being the only animal possessing *two hands*. Recently the tendency has been to revert to the classification of Linnaeus, and to place man with all monkeys, lemurs, and bats in the order *Primates* (see *BIMANA*, *MAMMALIA*). At first sight it might be considered that the so-called *Quadrumanans* or four-handed animals (monkeys, &c.) were better equipped than those which possess only two hands, but this is far from being the case. None of the four hands are adapted to the variety of actions which the human hand is capable of performing, and they are all, to some degree, required for support and locomotion; so that, while in the higher

Fig. 1.—



forms of the quadrumanans the extremities present an approximation in structure to those of man, in the lower they gradually tend to resemble the ordinary quadrupedal type. 'That,' says Cuvier, 'which constitutes the *hand*, properly so called, is the faculty of opposing the thumb to the other fingers, so as to seize upon the most minute objects—a faculty which is carried to its highest degree of perfection in man, in whom the whole anterior extremity is free, and can be employed in prehension.' The peculiar prehensile power of the human hand is chiefly dependent upon the length, power, and mobility of the thumb, which can be brought into exact opposition to the extremities of all the fingers, whether separately or grouped together.

The general arrangement of the bones of the hand will be understood by a reference to fig. 1.

In fig. 2 we have a diagram showing the way in which the bones of the hand are arranged. The carpal bones (3 to 10 in the figure) are eight in number, and are arranged in the wrist in two rows. The first or upper row consists practically of three bones (3, 4, 5), the fourth (6) being regarded as belonging to the class of *Sea-*



Fig. 2.—Diagram of the Bones of the Hand, with the ends of the Radius and Ulna (after Humphry):

1, end of radius; 2, end of ulna; 3, scaphoid; 4, semilunar; 5, cuneiform; 6, pisiform; 7, trapezium; 8, trapezoid; 9, magnum; 10, uncliform; 11, 11, metacarpal bones; 12, 12, first row of phalanges; 13, 13, second row; 14, 14, third row; 1, thumb; 11, forefinger, &c.; v, little finger.

hand. The inner (5) of the carpal bones bears the little and the next (the ring) finger (v and iv), and constitutes with them the inner division of the hand, while the middle one (4) bears the middle finger (iii), and belongs to the middle division of the hand. We likewise see from this figure, and also from fig. 1, that the two outer bones (3 and 4) are connected with the radius, while the inner bone (5) is connected (indirectly by a thick ligament) with the ulna.

The carpal bones are so arranged that the carpus presents a dorsal convex surface, upon which the tendons of the extensor muscles of the fingers play, and a palmar concave surface on which the tendons of the flexor muscles lie. The several bones are joined to one another—each bone being united to three or more others—by a large extent of surface, and are girded together by strong ligamentous bands. The wrist is thus as strong as if it had been constructed of one solid piece of bone, while the slight gliding movements which occur between the several bones give it an elasticity which serves to break the shocks that result from falls upon the hand. The uppermost surface of the first row of carpal bones is convex, and this convex surface is received into a wide cup or socket, formed by the lower articular surface of the radius and by a ligament passing from that bone to the ulna. Like the great toe, the thumb has only two phalanges, while each of the other digits has three.

For the different directions in which the arm and hand collectively can be moved, see the description of the construction and movements of the shoulder and elbow joints at ARM. Movements of the forearm and hand, to which there is virtually nothing analogous in the leg, are those of 'pronation and supination.' In *pronation* (derived from *pronus*, 'with the face downwards') we turn the palm of the hand downwards, as in picking up any object from the table; in *supination* (derived from *supinus*, 'with the face upwards'), we turn the palm upwards, as for the purpose of receiving anything that may be placed in it.

These movements of pronation and supination are so important to the usefulness of the hand that we must notice the muscles by which they are chiefly effected. One of these muscles passes from a projecting process on the inner side of the arm-bone at its lower end to the outer edge of the middle of the radius. Its contraction causes the radius to roll over, or in front of, the ulna. It thus pronates the hand, and is called a *pronator* muscle. Another crosses from the front of the lower end of the ulna to the corresponding part of the radius. Its shape and its action are indicated by the name *pronator quadratus*. Another muscle passes from a projecting process on the outer side of the arm-bone and from the outer aspect of the ulna to the outer surface of the radius near its upper part. It runs therefore in an opposite direction to the former muscle, and produces an opposite effect, rolling the radius and the hand back into the position of supination. Hence it is called a *supinator* muscle (see fig. 3). The fourth is a very powerful muscle termed the *Biceps* (q.v.), which not only bends the elbow, but, from the mode in which its tendon is inserted into the inner side of the radius, also rotates the

hand; and it gives great power to that movement. When we turn a screw, or drive a gimlet, or draw a cork, we always employ the *supinating* movement of the hand for the purpose; and all screws, gimlets, and implements of the like kind are made to turn in a manner suited to that movement of the right hand, because mechanics have observed that we have more power to supinate the hand than to pronate it. Supination can only be performed to its full extent by man, and even in man it is not the natural or habitual position; monkeys can partially effect the movement, and in most of the lower animals the part corresponding anatomically to the hand is constantly in a state of pronation.

The movements of which the hand itself, without reference to the arm, are capable, are very numerous, and in this respect differ considerably from the corresponding movements of the foot. Thus we can bend the fingers down upon the palm, or we can extend them beyond the straight line; we can separate them from one another to a considerable extent, and we can close them with considerable force. The wrist and hand are bent forwards or flexed upon the forearm by three muscles which pass downwards from the inner condyle or expanded end of the humerus, and are termed the *radial flexor*, the *ulnar flexor*, and the *long palmar* muscles. The first two of these muscles are inserted into wrist-bones on the radial and ulnar sides respectively, while the third expands into a fan-like fascia or membrane in the palm of the hand, and thus serves both to support the skin of the palm and to protect the nerves and vessels which lie below it. Beneath the palmar fascia lie two sets of flexor muscles of the fingers, and they present so beautiful a mechanical arrangement as to merit special notice.

The *superficial* or *perforated flexor* muscle passes down the front of the forearm, and divides into four tendons, which become apparent after the removal of the palmar fascia, and are inserted into the second phalanges of the fingers, each tendon splitting at its termination, to give passage to the similar tendons of the *deep* or *perforating flexor* muscle, which passes from the upper part of the ulna to be inserted into the last phalanx of each finger. This arrangement of the tendons of the superficial and deep flexor muscles is shown in fig. 4. To these flexor muscles

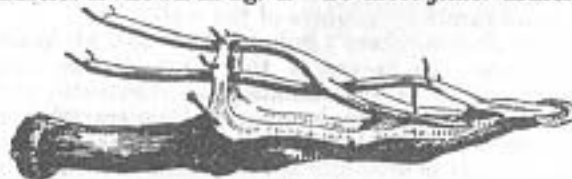


Fig. 4.

To show the perforation of one of the tendons of the superficial flexor muscle (which is inserted into the second phalanx), in order to allow the corresponding tendon of the deep flexor to pass onwards to be inserted in the last phalanx.

correspond the common *extensor* muscle of the fingers, which, like the flexors, divides into four tendons, one for each finger. Besides these, there is a special *extensor* of the index-finger, a series of muscles forming the ball of the thumb, which move that organ in almost every direction, and various small muscles giving lateral and other movements to the fingers.

It is sufficient to observe that the hand is very richly supplied with blood-vessels and nerves, without entering into any anatomical details on these points. There is no part of the body where the sense of touch is so acute as at the tips of the fingers; but we defer to the article TOUCH the consideration of the special arrangements which make this part of the hand peculiarly important in relation to our knowledge of external objects.

As a measuring standard for the height of horses a hand is a palm-breadth, assumed to be four inches.



Fig. 3.—The superficial Muscles of the Forearm:

1, biceps; 2, tendon of biceps; 5, the radial flexor of the wrist; 6, the long palmar muscle, spreading out (at 9) into the palmar fascia; 8, the ulnar flexor of the wrist; 10, the long supinator muscle.

Our notice of the comparative anatomy of the Foot (q.v.) renders it unnecessary to trace the modifications presented in the lower animals by the bones corresponding to those of the human hand, as the carpal and metacarpal bones with their phalanges undergo adaptations of form to meet the individual wants of the animal, very much in the same manner as the tarsal and metatarsal bones and their phalanges. Thus, the reader will readily see that the so-called knee of the horse, for example, is the carpus, and he will have no difficulty in tracing the metacarpal bones and phalanges.

Harmonic Engine, an invention of Edison's, in which the energy of an electric current is used, by means of two small electromagnets, to keep up the vibrations of a large and heavily weighted tuning-fork. The arms of the tuning-fork are connected with two pistons which work a miniature pump, and this may compress air, which, in its turn, can drive sewing-machines or do other light work.

Hartshorn, the term given in pharmacy to the antlers of the Red Deer or *Cervus elaphus*. Its composition is very different from that of persistent horns, as those of the ox, for example, and is identical, or nearly so, with that of bone. The products of its distillation, containing among other things, ammonia, were formerly much used in medicine, under the titles of oil of hartshorn, volatile salt of hartshorn, spirits of hartshorn, &c.; but they are now replaced by a solution of ammonia and carbonate of ammonia, the sal volatile of the shops. See AMMONIA.

Hashish, from which the word *assassin* is derived, is an Arabian preparation of Indian hemp, known in India as *bang* or *siddhi*. It consists chiefly of the leaves and stalks of *Cannabis indica*. The medicinal value of the preparations of Indian hemp is treated in another article; see HEMP (INDIAN). It is the physiological action which will now be specially noticed. The drug is used in the East in various ways. Sometimes it is smoked alone or with tobacco. At other times beverages are prepared from it, or it is taken in the form of lozenges or electuaries. The *majoon* of Calcutta, the *mapouchari* of Cairo, and the *dawames* or *dawames* of the Arabs are preparations of this kind. The effects differ according to the dose and the idiosyncrasy of the individual. Some become pugnacious, while others fall into a state of reverie. After small doses there is a great tendency to causeless merriment. In most cases there is an extraordinary susceptibility to hallucinations of various kinds, their nature depending largely on the cast

of mind of the person, and to some extent on his surroundings. Time, distance, and sound are no longer correctly judged of. A minute may have compressed into it the action of a month, a hand-breadth may stretch out to a mile, and the ripple of a brook may swell into the roar of Niagara. Although the dreams produced in Orientals by the drug are often of a voluptuous nature, this is by no means a universal effect, and among Europeans they have not this character. The stage of hallucination is generally succeeded by a stage of deep slumber with diminished sensibility. The unpleasant after-effects of opium seem to be absent; but the use of hashish has the inevitable demoralising effects of all such indulgences.

Heart, the central organ of the circulatory system, acting as a force and suction pump in relation to the blood-vessels. It always lies dorsally in Invertebrates, ventrally in Vertebrates, and arises from the strong development of one or more blood-vessels. In Vertebrates, the resulting cylinder, lying in the throat region of the embryo, is divided into receiving and expelling portions, *auricle* and *ventricle* respectively, and the whole is enclosed in a more or less marked cavity or ensheathing double bag, the *pericardium*. By curvature and folding, by formation of partitions and ingrowth of valves, the three or four chambered hearts of the higher vertebrates arise. It will be enough to describe the general structure and function of the heart in man.

The human heart lies ventrally in the chest, between the two lungs; it has a broad end or 'base' directed upwards and backwards, and a pointed end or 'apex,' turned downwards, forwards, and to the left; it is kept in position by the attachment of the ensheathing pericardium to the upper surface of the Diaphragm (q.v.), and by the large blood-vessels which enter or leave its four chambers; its total size is approximately equal

to that of its owner's closed fist. There are two receiving chambers or auricles, of which the right receives all the impure blood brought by the *venæ cavae* from head and body and by the *coronary vein* from the substance of the heart itself, while the left is filled with purified blood brought by the pulmonary veins from the lungs. The auricles pass their contents to the two driving chambers or ventricles, of which the right pumps the impure blood to the lungs, and the left sends the pure blood to the head and body. The ventricles are larger than the auricles, and have strong muscular walls proportionate to their harder work. The left ventricle is stronger than, and partially surrounded by, the thinner right chamber. The right auricle opens into the right ventricle by an aperture guarded by a triple (*tricuspid*) valve, whose three membranous lappets are attached to tendinous cords (*chordæ tendineæ*) arising from muscular processes (*musculi papillares*) on the walls of the ventricle. The opening from the left auricle into the left ventricle is similarly guarded by a double (*mitral* or *bicuspid*) valve. These valves on each side prevent the passage of blood from ventricle to auricle. At the base of the pulmonary artery on the right and of the aorta on the left, there are three pocket-like (*semilunar*) valves, which prevent backflow from vessels to ventricles.

When the heart is at work, the simultaneous contraction of the two auricles (i.e. of the muscle fibres on their walls) is followed by a similar contraction of the ventricles, and this by a pause or passive interval of re-expansion, after which the rhythm of contraction recommences. In the contraction of the auricles, the mass of blood in the large veins will not permit of a backflow in a peripheral direction, so that virtually all the contents of the auricles pass into the respective ventricles, which at that moment are flaccid and uncontracted. As the ventricles fill, the valves between them and the auricles are partly closed, and this is perfectly accomplished when the contraction of the ventricle sets in. As no blood can then pass back from ventricle to auricle, the energy of ventricular contraction is directed to overcoming the resistance of the semilunar valves guarding the entrance to the pulmonary artery and the aorta, which are moreover elastic vessels full of blood. The state of contraction in auricle or ventricle is called the *systole*; the state of passive relaxation and expansion the *diastole*, and it is evident that by the systole of the auricles the ventricles are filled, and that by the systole of the ventricles their contents are for the most part forced into the arterial systems of lungs



Fig. 1.—Section of the Human Heart (after His):

A, right auricle; B, right ventricle; C, left ventricle; D, left auricle; E, partition between the two ventricles. Between the auricles and ventricles on right and left, the tricuspid and mitral valves with their cords and associated muscles are shown.

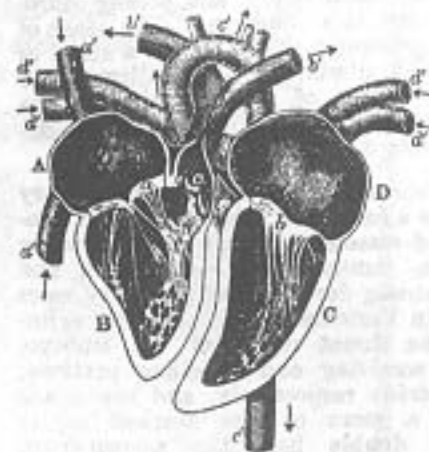


Fig. 2.—Diagram of Heart halved and laid open (after Debievre):

A, B, C, D, as in fig. 1. a, part of tricuspid valve; b, part of mitral; c, semilunars at base of pulmonary artery. a', a'', inferior and superior venæ cavae entering A; b', b'', pulmonary arteries proceeding from B; c', c'', aorta proceeding from C; d', d'', pulmonary veins entering D.

passive relaxation and expansion the *diastole*, and it is evident that by the systole of the auricles the ventricles are filled, and that by the systole of the ventricles their contents are for the most part forced into the arterial systems of lungs

and body. As the heart usually beats about seventy-two times a minute, the cycle of events just noted lasts about $\frac{1}{4}$ th of a second, of which the systole of the ventricle lasts about $\frac{1}{6}$ th, that of the auricle perhaps $\frac{1}{10}$ th, and the passive interval about $\frac{1}{2}$ th of a second.

The activity of the heart has several external indices, such as the *beating*, seen and felt between the fifth and sixth rib on the left side, due to contraction of the ventricles, which makes the 'apex' of the heart strike against the pericardium, and through this on the wall of the chest. There are also sounds produced by the heart: (a) the longish dull sound probably caused by the contraction of the muscular fibres of the ventricles and the tension of the valves between these chambers and the auricle; (b) the sharp sound due to the sudden closure of the semilunar valves when the contraction of the ventricles ceases. The heart sounds are of great importance in the diagnosis of disease of the heart. They may undergo various changes and may in some cases disappear or be replaced by or accompanied by *murmurs*. These murmurs are caused by the blood flowing through the orifices of the heart which have become changed by disease. At a distance from the heart, the *pulse* or regular dilatation of an elastic artery is a familiar index. The heart is under the control of three sets of nerves: (a) from ganglia in its own substance, apparently essential to the regular rhythm of contraction; (b) from the sympathetic system, apparently affecting rapidity of action; (c) from the pneumogastric or vagus nerve, coming directly from the brain, apparently with arresting power. See AORTA, ARTERIES, BLOOD, CIRCULATION; text-books of Anatomy by Quain, Turner, Mivart, Macalister, &c.; of Physiology by Foster, Huxley, Landois and Stirling, &c.

DISEASES OF THE HEART are either those affecting the various tissues composing the heart, or the nervous arrangements governing the heart.

(1) *Diseases of Structures composing Heart* may be primary or secondary.

(a) *Primary Diseases*.—All the various tissues of the heart may be primarily affected. The *Pericardium* (sac surrounding heart) may be affected with inflammation (*pericarditis*). This is by no means an uncommon condition in rheumatic fever, while it also occurs in connection with some of the acute exanthemata. Fluid tends to be effused into the sac, and this produces great impairment of the heart's action. The condition frequently leads to a fatal termination. Various *tumours* may occur in connection with the pericardium.

The *Myocardium* (muscular wall of heart) may also be affected with inflammation leading to very irregular and impaired action of the heart, and often to death. This is known as *myocarditis*, and if the fatal termination does not ensue in the acute stage of the disease, the wall of the heart is apt to be left in a weakened condition due to the pathological changes set up in the course of the inflammation. The myocardium may occasionally be the seat of *tumours*. The muscular substance of the heart may undergo a *fatty degeneration*, which may produce death either from failure of the heart, or more rarely by rupture of the wall.

The *Endocardium* (lining membrane of heart; also forms the valves of the heart) is the most common seat of inflammation in rheumatic subjects and in individuals suffering from scarlet fever or from some other of the exanthemata. This *endocarditis* is specially apt to attack the valves of the left side of the heart, and to lead to deformity and the imperfect action of these important structures. When this occurs the well-known train of symptoms commonly associated with heart disease are apt to appear—breathlessness, palpitations, irregular heart's action, dropsy, albuminuria, &c.; while the various signs of valvular disease, among the most important of which is the alteration in the sounds of the heart, and the development of murmurs may also be determined. In many cases, however, in spite of disease of the valves, the heart may continue to act satisfactorily. But there is always a great danger of its proving inadequate to the additional work thus put upon it, and of its suddenly failing under any extra strain.

There is one peculiar form of inflammation of the endocardium known as *acute ulcerative endocarditis* which is exceedingly fatal, and which is due to the development of micro-organisms in the heart. Certain slow degenerative changes may also affect the endocardium, more especially where it composes the aortic valves (*Atheroma*).

In all inflammatory affections of the heart there is a tendency for all the structures to be involved

at one and the same time.

(b) *Secondary Diseases*.—As the result of various morbid states of other parts of the body, the heart, and more especially its muscular wall, may become secondarily affected. Thus in *fever* the muscular substance of the heart manifests the condition of *cloudy swelling*, and thus becoming weakened tends to yield to the pressure of blood inside the heart, and to undergo dilatation. This state of the organ is frequently accompanied by the development of murmurs due to the imperfect action of the valves between the auricles and ventricles allowing the blood to flow backwards through the orifices. At the same time the various symptoms of disturbed circulation are developed.

In the various forms of *anæmia* (bloodlessness), whether primary or secondary to other diseases, the muscle of the heart becomes debilitated, and a similar series of signs and symptoms to those just described make their appearance.

In certain diseases in which the blood pressure is raised (*Bright's Disease*), or when any condition throws extra work on the heart for a considerable period, the organ becomes *hypertrophied*—i.e. increased in size and strength. This is well seen when the valves are diseased, and the muscular substance is well nourished.

(2) *Derangements of Nervous Mechanism of Heart*.—As a result of many totally different conditions the sensory nervous mechanism of the heart may be affected, and give rise to pain or to various sensations in the region of the heart. These sensations are not, however, always indicative of organic disease of the organ.

A peculiar set of symptoms, known as *angina pectoris*, are treated more fully under a separate head. The patient suffers from attacks, the chief symptom of which is a dreadful feeling of impending death, usually with cardiac pain. When occurring as the result of organic heart disease these symptoms are most commonly connected with disease of the aortic valves.

The various nervous arrangements presiding over the movements of the heart may also become deranged, and lead to increased or diminished heart's action or to irregular action. The last is the most frequent, and is a very common accompaniment of organic disease, though it frequently occurs in individuals entirely free of any such condition. Nervous and gouty individuals and those addicted to the excessive use of tobacco are common sufferers from such *palpitations*.

The words 'broken heart' seem to suggest a form of heart disease. But of course the expression arose out of the long prevalent and now wholly obsolete view that the heart is in some way the seat of the affections—a view inevitably suggested by the quickening of the pulse under emotion, or its temporary stoppage from a sudden shock.

Hemlock (*Conium*), a genus of plants of the natural order Umbelliferae, having compound umbels of small white flowers, small general and partial involucre, the limb of the calyx merely rudimentary, and a compressed ovate fruit with five prominent wavy ridges and no *vitta*. The best-known and only important species is the Common



Flowers and Root of Common Hemlock (*Conium maculatum*): c, a flower; d, a seed.

or Spotted Hemlock (*C. maculatum*), which grows by waysides, on heaps of rubbish, and in other similar situations in Britain and on the continent of Europe, in some parts of Asia, and now also as a naturalised plant in North America and in Chili. It has a root somewhat resembling a small parsnip; a round, branched, hollow, bright-green stem, 2 to 7 feet high, generally spotted with dark purple;

the leaves large, tripinnate, of a dark shining green colour; the leaflets lanceolate, pinnatifid. All parts of the plant are perfectly destitute of hairs, and it is the only British species of the order Umbelliferae which has the stem smooth and spotted with purple. Both the general and partial umbels have many rays. The general involucre consist of several small leaflets, the partial involucre of three small leaflets, all on one side. The whole plant has a nauseous smell, particularly if rubbed or bruised. The leaves and fruit are the parts of the plant employed in medicine. The former should be gathered just before the time or at the commencement of flowering, and after the removal of the larger stalks they should be quickly dried by a heat not exceeding 120°. They should then be preserved in perfectly closed tin canisters. The fruit is gathered when fully developed, but still green, and should be carefully dried.

The most important ingredient in hemlock is the alkaloid conine, a volatile, colourless, oily, strongly alkaline substance, $C_8H_{17}N$, but it also contains two other alkaloids—methylconine and conhydrine. The fruit contains about one-fifth per cent. of it, the other parts of the plant merely traces. It is obtained by distilling the seeds with water which contains a little potash in solution; the conine passes over with the water in the form of a yellowish oil, and is purified by redistillation. Conine has lately been prepared artificially by Schiff. Conhydrine, $C_8H_{17}NO$, is a solid volatile alkaloid, and is much less poisonous than conine. Conine and methylconine are extremely poisonous, and cause death by their action on the nervous system. The action of conium depends of course on the combined effects of the active principles contained in the plant. The symptoms of conium poisoning are weakness and staggering gait, passing on to paralysis, which gradually passes up the cord until it reaches the respiratory centre, when death ensues. Dilatation of the pupil, ptosis, and asphyxial convulsions are symptoms also seen.

In medicine, it is given internally as a sedative to the nervous system in chorea, incontinence of urine, paralysis agitans, and other affections. It is also employed as a vapour to relieve cough. It may be administered internally in the form of powder (of the leaves), succus, tincture, or extract, while externally it may be applied as a soothing application to ulcers, painful piles, &c., in the form of ointment or poultice. The succus is considered the best preparation, the others often containing no active principle.

In cases of poisoning by hemlock, the evacuation of the stomach is the first thing to be attended to. Among the ancient Greeks, poisoning by hemlock was a common mode of death for condemned criminals, and thus it was that Socrates died.—Water Hemlock, or Cowbane (*Cicuta virosa*), is also an umbelliferous plant, of a genus having much-vaulted umbels, a five-toothed calyx, and almost globose fruit, each carpel with five broad flattened ribs and evident single *vittæ*. Water hemlock grows in ditches, on the margins of ponds, and wet grounds in Europe and the north of Asia. It is more common in Scotland than in England. It has a large fleshy white root, covered externally with fibres; an erect much-branched stem, 2 to 5 feet high; tripinnate leaves, with linear-lanceolate regularly and sharply serrated leaflets; no general involucre, or only a single small leaflet, partial

Water Hemlock (*Cicuta virosa*).

involucre of many short narrow leaflets; and white flowers. It contains an active principle, *Cicutarine*, and an essential oil. It causes tetanic spasms, insensibility, vomiting, and diarrhoea. Fatal results have occurred from eating the root.

Another species, *C. maculata*, is common in North America, growing in marshy places. It has a spotted stem, like that of true hemlock, the name of which it very generally receives in North America. The leaves are triternate, the leaflets ternate. It is a very poisonous plant, and is the cause of many deaths.—The *Cicuta* of the Romans was the *Conium* of modern botanists (Gr. *konion*), as water hemlock does not grow in Italy or Greece. The ornamental plant, the so-called Giant Hemlock, which in good rich soil reaches a height of 12 to 15 feet in three months, is not really a hemlock at all, but a giant Cow-parsnip (q.v.).

Hemp (*Cannabis*), a genus of plants of the natural order Cannabinaceae (q.v.), having the male and female flowers on different plants; the male flowers with five-partite calyx and five stamens; the female flowers with a spathe-like calyx of one leaf, rolled round the ovary and partially split along one side, and two threadlike stigmas. There is only one known species (*C. sativa*), varying considerably, however, from soil, climate, and cultivation. It is an annual plant, a native of the warmer parts of Asia, but has been cultivated in Europe from the earliest historic times, and is now naturalised in many parts of Europe and America. Like flax, it adapts itself wonderfully to diversities of climate, and is cultivated equally under the burning sun of the tropics and in the northern parts of Russia.

Common Hemp (*Cannabis sativa*), male plant.

It is, however, readily injured by frost, particularly when young; and in many countries where it is cultivated it succeeds only because the warmth of the summer, though of short duration, is sufficient for its whole life. Hemp varies very much in height, according to the soil and climate, being sometimes only 3 or 4 feet, and sometimes 15 or 20 feet, or even more. Notwithstanding the coarseness of its leaves, it is an elegant plant, and is sometimes sown on this account in shrubberies and large flower-borders. The stem is erect, more or less branched; the leaves are five to nine fingered. The flowers are yellowish-green, small, and numerous; the male flowers in axillary racemes on the upper parts of the plant; the female flowers in short axillary and rather crowded spikes. The female plants are higher and stronger than the male. The stem of hemp is hollow, or only filled with a soft pith. This pith is surrounded by a tender, brittle substance, consisting chiefly of cellular tissue, with some woody fibre, which is called the *reed*, *boon*, or *shove* of hemp. Over this is the thin bark, composed chiefly of fibres extending in a parallel direction along the stalk, with an outer membrane or cuticle.

Hemp is cultivated for its fibre in almost all countries of Europe, and in many other temperate parts of the world, most extensively in Poland, and in the centre and south of European Russia, which are the chief hemp-exporting countries. French hemp is much esteemed in the market, as is also that of England and Ireland, of which, however, the quantity is comparatively inconsiderable. *Bolognese Hemp* and *Rhenish Hemp* are varieties remarkable for their height; and a fibre of very fine quality, 8 or 9 feet long, is known in commerce by the name of *Italian Garden Hemp*. In the United States most of the hemp is grown in Kentucky. In England the cultivation of hemp is almost confined to Lincolnshire, Holderness in Yorkshire, and a few other districts.

of which the moist alluvial soil is particularly suited to it. In cultivating hemp it is very necessary to have the soil so rich, and to sow the seed at such a season, that the plants shall grow rapidly at first, as they thus form long fibres. A crop of short scrubby hemp is almost worthless. The finer kinds of hemp



Common Hemp, female plant.

are used for making cloth, the coarser for sail-cloth and ropes. Hemp sown thin produces a coarser fibre than hemp sown thick. Something also depends on the time of pulling, for the crop is pulled by the hand. When a rather fine fibre is wanted, and the seed is not regarded, the whole crop is pulled at once, soon after flowering; otherwise, it is usual to pull the male plants as soon as they have shed their pollen, and to leave the female plants to ripen their seed, in which case the fibre of the female plants is much coarser. The treatment of hemp by *retting*, &c. is similar to that of Flax (q.v.). The fibre of hemp is generally used for coarser purposes than that of flax, particularly for sailcloth, pack-sheet, ropes, and the caulking of ships.

The seed of hemp is produced in great abundance. It is commonly sold as food for cage-birds; and birds are so fond of it that not only the ripening fields, but the newly-sown fields, must be carefully guarded against their depredations. A fixed oil, *oil of hempseed*, is obtained from it by expression, which is at first greenish-yellow and afterwards yellow, and has an acrid odour, but a mild taste. This oil is used in Russia for burning in lamps, although the wick is apt to get clogged, also for making paints, varnish, and a kind of soft soap.

Hemp is cultivated in warm countries not so much for its fibre as for a resinous secretion, which has narcotic or intoxicating qualities (see *HASHISH*). Hemp is also used as a therapeutic agent under the name of Indian Hemp, or Bhang, and may be administered in the form of resinous extract or of tincture; and it is usually prescribed (like opium) for its hypnotic, anodyne, and antispasmodic properties. Although less certain in its action than opium, it possesses these advantages over that drug—that it does not constipate the bowels, create nausea, or check the secretions, and that it is less likely to occasion headache.

The name Hemp (Ger. *Hanf*) is from the Greek and Latin *cannabis*, and that from Sanskrit *çana*. The name hemp is often extended with some distinctive prefix to many of the fibres used for ropes and coarse fabrics—Sunn Hemp, Manilla Hemp, Deccan Hemp, Sisal Hemp, &c. See *APOCYNACEÆ*, *BOWSTRING HEMP*, *FIBROUS SUBSTANCES*.

Henbane (*Hyoscyamus*), a genus of plants of the natural order Solanaceae, having a five-toothed calyx, an irregular, funnel-shaped corolla, and a capsule opening by a lid and enclosed in the hardened calyx. The species are mostly annual and biennial herbaceous plants, and natives of the countries near the Mediterranean Sea. The only species found in Britain is the Common Henbane (*H. niger*), which is not uncommon in waste places and in the neighbourhood of towns and villages, particularly in calcareous soils, and on the sandy shores of Scotland. It is an annual plant, somewhat bushy, about 2 feet high, with large sinuated or sharply-lobed leaves without leaf-stalks, and large dingy yellow flowers with purplish veins. The whole plant is covered with unctuous hairs, and has a nauseous smell, which gives warning of its strong narcotic poisonous quality. Cases of poisoning by henbane are, how-

ever, not rare, but are more frequently owing to the proceedings of quacks than to any mistake of the plant for an esculent.

The seeds contain in largest quantity the peculiar alkaloid on which the properties of the plant chiefly depend, *Hyoscyamia* or *Hyoscyamin*, which crystallises in stellated acicular crystals of a silky lustre.



Henbane (*Hyoscyamus niger*).

The symptoms of poisoning by henbane are similar to those produced by other narcotic poisons, and the proper treatment is the same as in cases of poisoning by opium. In medicine henbane is employed both externally and internally. The leaves are the part commonly used; they are gathered and quickly dried when the plant is in full flower. Fomentations of henbane are applied to painful glandular swellings, parts affected with neuralgia, &c., and are often found to afford relief. An extract of henbane is sometimes employed instead of belladonna to dilate the pupil of the eye. Tincture and extract of henbane are often administered in cases of annoying cough, spasmodic asthma, and other diseases requiring sedatives and anti-spasmodics. Henbane is also employed to calm mental irritation and to induce sleep. For many cases it has one great advantage over laudanum, in not producing constipation. The smoke from the burning seeds of henbane is sometimes introduced into a carious tooth to relieve toothache.

The other species of henbane possess similar properties. The dried stalks of *H. albus* are used by smoking in Greece to allay toothache.

Hepar (Gr. *ἥπαρ*, 'the liver') is the name given by the older chemists to various compounds of sulphur, from their brown, liver-like colour. *Hepatic* means belonging to the liver; as, *hepatic* artery, vein, duct, &c. *Hepatica* is a term for medicines which affect the liver and its appendages.

Hernia (Lat.; probably from Gr. *ἕρνος*, 'a sprout'), in its widest sense, signifies a protrusion, through an abnormal or accidental opening, of any organ from its natural cavity. Although hernia may occur in many parts of the body, the word, used by itself, is restricted to signify protrusion of the abdominal viscera, the condition popularly called *rupture*.

The way in which hernia may arise will be readily understood if we bear in mind that the abdominal viscera are subject to constant pressure from the diaphragm and other surrounding muscles. If at any point the walls of the belly are not sufficiently strong to resist this pressure some portion of the viscera is driven through them, and a hernial tumour is formed. Certain parts of the abdominal walls, especially the inguinal and crural rings, and the umbilicus, being weaker than others, hernia most frequently occurs at these points. In some instances hernia is congenital, from abnormal deficiency of the walls; in other cases it may arise at any period of life as a result of violent bodily exertion. Sex, age, and occupation seem to have a marked influence in predisposing to

hernia. Men are far more liable (in about the proportion of four to one) to this disease than women; though they are less so to those forms of the affection known as femoral and umbilical hernia. According to Malgaigne, in France one man in thirteen, and one woman in fifty-two, are the subjects of hernia. In respect of age he found that the liability is least about the age of thirteen

(one in seventy-seven), after which it progressively increases until the close of life, rising at seventy to seventy-five to one out of every three.

A hernia is almost always composed of a *sac* and its *contents*. The sac is a portion of the Peritoneum (q.v.) corresponding to the aperture at which the hernia protrudes. It is pushed forward by the protruding viscera, and forms a pouch. The contents vary greatly, but generally consist of a portion of the small intestine (particularly of the ileum), forming the variety of hernia known as *enterocele*. Omentum is often found in hernial sacs, either with or without intestine. Besides the viscera, the sac always contains a certain quantity of fluid secreted by its interior. Hernia is divisible (1) into *reducible*, or returnable into the abdomen, *irreducible*, and *strangulated*; and (2), according to its situation, into *inguinal*, *femoral*, &c.

The treatment of reducible hernia may be palliative or radical. The palliative treatment consists in the application of a truss (see below) to retain the protrusion within the cavity of the abdomen. Each particular kind of hernia (femoral, umbilical, &c.) requires its special form of truss; and before applying it the hernia must be reduced by placing the patient on his back, relaxing the muscles by bending the thigh upon the abdomen, and pressing the tumour back in the proper direction. The truss should then be put on, and should be worn during the whole of the day; and if the patient will submit to wear it (or a lighter one) during the night, so much the better. The means that have been contrived to effect a radical cure are too purely surgical for description in these pages. Below the age of puberty, and if the hernia is recent, a radical cure is sometimes effected by wearing the truss for two or three years.

In irreducible hernia the protruded viscera cannot be returned into the abdomen, but there is no impediment to the passage of their contents or to their circulation. In these cases the patient is often liable to dragging pains in the abdomen, and to attacks of vomiting, in consequence of the movements of the abdominal organs being checked by the omentum or intestines being fixed. There is also constant danger of this hernia passing into the strangulated form. The treatment may be either palliative or radical. The palliative treatment consists in the employment of a truss with a hollow pad that shall embrace the hernia, and prevent any additional protrusion. An irreducible hernia may sometimes be converted into a reducible one by keeping the patient in the recumbent position, and on very low diet, for two or three months; at the same time keeping the bowels open by laxatives and injections, and maintaining equable pressure over the tumour. Radical cure is, as in the case of reducible hernia, by operation.

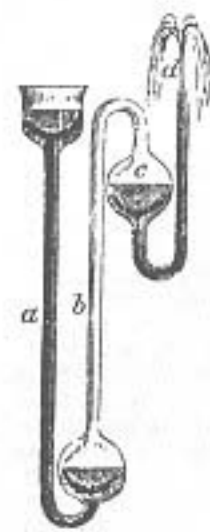
Hernia is said to be *strangulated* when a portion of intestine or omentum that is protruded is so tightly constricted that it not only cannot be returned into the abdomen, but has its circulation arrested. This form is highly dangerous, because, if relief is not speedily afforded, the strangulated part becomes gangrenous. The causes of strangulation are various, but this condition most commonly arises from a sudden violent effort, by which a fresh portion of intestine is driven into a pre-existing hernia, which it distends to such a degree as to produce this complication. The most prominent early symptoms are flatulence, colic pains, &c. They are succeeded by vomiting first of the contents of the stomach, then of mucus and bile, and lastly of fecal matters, owing to inverted peristaltic action. If relief is not obtained the inflammation that commences in the sac extends to the peritoneum, and the ordinary signs of peritonitis appear. After a variable time comes gangrene or mortification of the part, and the patient speedily sinks.

The surgeon first tries to return the intestine, as in the preceding cases. This manipulation, termed the *taxis*, may be assisted by the internal use of chloroform, inhaled till it produces complete relaxation of the muscles, by the hot bath, &c. If this fails he must have recourse to the knife to divide the constriction.

The necessity of having recourse to a suitable truss the moment that the slightest protrusion shows itself in any of the parts liable to hernia cannot be too strongly urged as a matter of necessary general knowledge. At whatever period of life a hernia occurs, if properly attended to and judiciously supported, it usually gives little trouble, and if it occurs in early life, it may often be cured; whereas, if it be neglected, increase of bulk, and,

subsequently, diseased states of the parts, often terminating in death, will almost certainly occur. A *truss* consists essentially of a pad or cushion attached to a metallic spring, with straps so arranged that its position may be retained during the varied postures of the body. A surgeon should always be consulted in the choice of the instrument. 'The practice,' says Mr Birkett, 'of leaving cases of rupture in the hands of mere tradesmen cannot be too strongly censured. Amongst the poor we constantly observe the lamentable effects of this proceeding.' Many varieties of trusses have been invented. There are occasional cases in which the common truss fails to support a rupture comfortably, and in these cases various instruments, for the most part the property of special instrument-makers, are often serviceable. The patient must expect to find the truss somewhat uncomfortable for a week or two, but will soon get used to it. The skin of the part upon which it presses should be regularly washed and bathed with eau de Cologne or spirit, as, without this precaution, boils are apt to form on it.

Hero OF ALEXANDRIA (Gr. *Ἡρόν*), a great mathematician and natural philosopher, was a pupil of Ctesibius, and flourished about 100 or 150 B.C. He seems to have invented a great number of machines and automata, among which are Hero's fountain; a steam-engine on the same principle as Barker's mill; a double forcing-pump used for a fire-engine, and various other similar applications of air and steam. Among his works which have



Hero's Fountain.

come down to us the most notable is on Pneumatics; Hultsch edited the remaining fragments of his geometrical works in 1864.—Another Hero, called Hero the Younger, who wrote on mechanics and astronomy, long had the credit of writing some of his namesake's books. According to some authorities he flourished at Alexandria in the 7th century A.D.; according to others, at Constantinople in the 10th.—

HERO'S FOUNTAIN is a pneumatic apparatus, through which a jet of water is supported by condensed air. A simple mode of constructing it by means of glass tubes and a glass-blower's lamp is shown in the annexed figure. The column of water in the tube *a* compresses the air in *b*; this presses on the surface of the water in *c*, and causes it to gush out at *d*.

Hippuric Acid, $C_9H_7NO_3$, is a compound of great interest both to the chemist and to the physiologist. It derives its name from its having been first discovered in the urine of the horse, and that fluid, or the renal secretion of the cow, affords us the best and readiest means of obtaining it. The crystals of hippuric acid are moderately large, colourless, but subsequently becoming milk-white, four-sided prisms, which are devoid of odour, but have a faintly bitter taste. They dissolve readily in boiling water and in spirit, but are only sparingly soluble in cold water and in ether. It is an abundant normal constituent of the urine of the horse, cow, sheep, goat, hare, elephant, &c., and most probably is to be found in the urine of all vegetable feeders. In the human urine of healthy persons living on an ordinary mixed diet it occurs in very small quantity, but it is increased by an exclusively vegetable diet, and in the well-known disease diabetes.

The hippuric acid occurring in the animal organism exists in combination with bases, and chiefly as hippurate of soda and hippurate of lime. The last-named salt can be obtained by the mere evaporation of the urine of the horse. The chief interest of the substance is that it was one of the first to be discovered of a long series of complex bodies, which we now know are formed synthetically in the animal body. Hippuric acid readily splits into benzoic acid and glycocholic acid. If benzoic acid is administered it is excreted as hippuric acid, combining with glycocholic acid in the body. In herbivorous animals the benzoic acid is largely derived from the food; in animal feeders even in starvation it occurs in small amount in the urine, and we must therefore conclude that its forerunners may be derived from the metabolism of the tissues. That certain bodies closely allied to

benzoic acid may be so formed has now been experimentally demonstrated, while glycolic acid can also be proved to be so produced. At one time the belief was entertained that these bodies were combined in the liver; but more recent research has shown that the synthesis chiefly takes place in the kidneys.

Hoofs. The healthy soundness of the horse's foot is mainly preserved by permitting it to grow uninjured by the rasp and knife (see HORSE-SHOING), and kept clean by being washed with cold water; all other applications are injurious and destroy the toughness of the 'horn surface.' Softness and brittleness of the hoof, which are fruitful sources of cracks and Corns (q.v.), may be remedied by placing the feet for several hours daily in thick woollen swabs, kept cool and moist by frequent applications of cold water, and by encouraging a more healthy growth of horn by occasional mild blisters round the coronary band. Cracks, or sand-cracks, as they are termed, mostly occur amongst horses much upon the road, cause lameness, and constitute unsoundness. When serious and recent, poulticing, thinning away of the crust about the crack, and perfect rest are essential. After the earlier heat and tenderness are removed a hot iron should be drawn at right angles to the crack, both above and below, so as to separate the diseased from the sound horn. Waxed thread or fine wire should be wound round the hoof, and a sound growth of horn stimulated by a blister round the coronary band. The horse's hoofs are too hard and coarse to be employed for the making of the better class of combs and buttons, for which purpose the hoofs of cattle, to the value of nearly £5000, are annually imported into Britain. They are, however, largely used by manufacturers of prussiate of potash and artificial manures. See FOOT.

Horn, a general term applied (1) to certain structures, whatever their composition, growing on the heads of oxen, sheep, giraffes, rhinoceroses, &c., and to similar structures on other animals such as beetles; (2) to a substance of a certain definite chemical composition forming 'horns,' hoofs, nails, claws, and other similar structures.

(1) Of horns as they exist among mammals there are two distinct classes: (a) horns formed of epidermal tissue; and (b) bony horns or antlers. (a) Epidermal horns are of two kinds. The horn of the rhinoceros, which is an example of the first kind, consists of a compact, uniform agglutination of epidermal fibres or bristles. The slightly concave base of the horn fits over a slightly-projecting roughened portion of the nasal bones underneath. In the growing horn, while the fibres at the back decay, new fibres are so added at the front and sides that, relatively to the fore-part of the head, the position of the horn remains always the same. In grown animals new material is added only at the base, and the whole outer surface is smooth and rounded. The horn is median in position and symmetrical in shape. In the female it is usually shorter and smaller. When a second horn is present it is usually shorter and smaller in size, and is situated behind the first one and on the frontal bones. If we imagine the rough part of the bone underneath and the vascular tissue immediately over it growing upwards into the epidermal horn and hollowing it out, we have the second kind of epidermal horn—the hollow horn found in the Cavicornia (Bovidae, Ovidae, Antilopidae). In the case of these horns the bony part, or horn core, is developed as an outgrowth from the frontal bone; in the Bovidae and Ovidae the cores are hollow or spongy, and their spaces communicate with the air-spaces in the frontal bones, while in the Antilopidae the cores are solid or only slightly excavated at the base. Hollow horns are usually unbranched and persistent, but in the Prong-horn Antelope (*Antilocapra americana*) the horny sheaths are shed annually while the bony cores grow and their vascular coverings persist and give rise to the new horns; these horns show, after the first year, a small branch or snag analogous to the brow-antler of the deer. In the Chickara (*Antelope (Tetracerus) quadricornis*), an Indian species of antelope, two pairs of horn cores are developed from the frontal bones. The gigantic extinct antelopes *Bramatherium* and *Sivatherium* had two pairs of horns like the *Antelope quadricornis*, and the hinder pair possessed the branched character now exhibited only by the Prong-horn. Hollow horns are found usually in both sexes, but in some genera of antelopes (*Tragelaphus*, *Cervicapra*, *Cephalophus*, &c.) only in the male. In



Front View of the Skull of the Ox, with the right Horny Sheath detached from the Core.

the Prong-horn the horns of the female are almost hidden in the hair of the head; they are small, short, and unbranched, as in the yearling buck. (b) Bony horns or antlers (see ANTLERS, and DEER) are of two kinds, exemplified by the horns of the deer and giraffe respectively. In these the horns are developed from membrane bones which grow up covered by the skin, and nourished by vessels from it. In the giraffe they grow just over the junction of the frontal with the parietal bones, and become united to them by means of cartilage. The integument over the antler is terminated by a tuft of coarser hair, and is persistent. Horns are present in both sexes, and the young giraffe is the only animal born with horns. The antlers of the deer differ from those of the giraffe in that the membrane bones become firmly united by bony growth to the frontal bones, the integument—or velvet—does not persist, and the horns are shed annually.

(2) True horny tissue is a modified form of epidermic tissue. The term includes not only true horn, as noted above, but also hoofs, nails, claws, hair, wool, beaks of animals generally, the carapace of tortoises, the scales of the pangolin, the spines of the hedgehog and the quills of the porcupine, the feathers of birds, the 'castors' of horses and other animals, and other epidermic thickenings and growths, whether occurring normally as the callosities over the breastbones of camels and the hips of some monkeys or pathologically as the 'corns' and 'horns' of the human subject. This tissue largely consists of an albuminoid substance termed 'keratin,' which is composed of carbon (from 50.3 to 52.5 per cent.), hydrogen (from 6.4 to 7 per cent.), oxygen (from 20.7 to 25 per cent.), nitrogen (from 16.2 to 17.7 per cent.), and sulphur (from .7 to 5 per cent.). Keratin may be obtained from the structures above enumerated by the successive action of boiling water, alcohol, ether, and dilute acids, and is probably a compound body that has not yet been resolved into its components. Viewed under the microscope, horny tissue is seen to consist of numerous parallel bundles of fine threads. These threads, under the action of a concentrated solution of caustic potash or soda, unfold into small plates which gradually expand into regular nucleated epidermic cells shown in the figure.



Cellular Structure of Horn.

Cattle are frequently dishorned to prevent them from constantly goring and injuring each other when confined in open courts; the whole or part only of the horn and horn core may be removed, but the usual method is total dishorning by sawing off the horns close to the head, at their junction with the skull. If the operation is skilfully performed, and if proper precautions be taken to prevent inflammation following, the operation is affirmed by many to be by no means a very painful one (much less so than many others, such as branding), the skin being the most sensitive structure involved. It should not therefore, it is argued, be considered within the category of cruelty to animals forbidden by law. In 1889, however, the Queen's Bench division decided against this view, the judges denouncing the practice as cruel and demoralising. The Scottish Court of Session in 1890 came to an opposite conclusion, which was appealed from.

HORN MANUFACTURES.—The horns of the ox, buffalo, sheep, goat, and antelope are hollow, tough, and capable of being split into flexible slices. Rhinoceros horn, though solid through nearly its whole length, resembles that of the ox in its nature. From the most remote ages the horns of animals have been employed by man for various purposes. Numerous examples of poniards, handles, pick-axes, dart-heads, 'batons of authority,' and imple-

ments of unknown use made of reindeer and red-deer horns have been found in river-gravels among other prehistoric remains of the Neolithic period. But the most remarkable of the productions of Neolithic man which have yet been found are pieces of reindeer horn and mammoth tusks with carvings or etchings of animals upon them.

Horns of the ox, as well as those of the sheep and goat, can be split up into sheets or plates after they have been soaked and boiled. When made very thin such plates were at one time used for window-panes, for the construction of lanterns, and for covering Hornbooks (q.v.). Two pieces of horn can also be welded together at the edges by steeping them in hot water and applying pressure. Another valuable property of horn is that when heated it can be pressed into a die or mould. In this way it is formed into ornamental handles for knives, forks, umbrellas, and walking-canes; also into drawer-knobs, spoons, boxes, buttons, and many other useful articles.

It may be stated here that the hoofs of oxen are likewise manufactured on a large scale into combs, and to some extent into other articles such as buttons.

In their natural form, but cleaned and polished, horns are used as drinking-cups and snuff-boxes, and in past times they were very largely employed for holding gunpowder. They also served as wind-instruments. Many of the Scotch powder-horns in use during the 16th and 17th centuries are beautifully and elaborately carved. A considerable number of these are illustrated in Drummond's *Ancient Scottish Weapons* (1881). In India buffalo and other horns are used for ornamental work of various kinds. Rhinoceros horn again is a favourite material with Chinese carvers, who form the base of it into elegant cups, and sometimes make a very effective ornament of the entire horn, which admits of being very boldly carved. The deer horn so much worked up at Sheffield into handles for carving and pocket knives is chiefly that of the Axis deer (*Cervus axis*) of India. Deer horns are employed in France and Germany to decorate furniture. In Great Britain the antlers or horns of the stag, the roe, and the fallow deer—generally with the skull attached—are favourite ornaments for the decoration of entrance-halls, and good examples of these are now somewhat costly.

Horology (Lat. *horologium*, Gr. *hōrologion*, 'a sun-dial,' 'a water-clock'; Gr. *hōra*, 'a season,' 'an hour,' and *-logion*, from *legein*, 'to tell'; compare Old Eng. *horologe*, Fr. *horloge*, 'a clock'), the science which treats of the construction of machines for telling the time. Although it is easy to look back to a period when time, according to the modern conception of it, as measured by hours and minutes and seconds, was unknown, yet we find progress early made in the measurement of larger periods of time, by observations of the heavenly bodies. Thus, time was early divided into years according to the apparent motion of the sun among the constellations; into months by the revolution of the moon round the earth; and into days by the alternate light and darkness caused by the rising and setting of the sun. It was long, however, before any accurate measure was found for a division of the day itself. The earliest measure employed for this purpose that we can trace is the shadow of an upright object, which gave a rough measure of time by the variations in its length and position. This suggested the invention of sun-dials (see DIAL). Another means early adopted for the measurement of short periods of time was by noting the quantity of water discharged through a small orifice in the containing vessel. Instruments for the measurement of time on this principle were called Clepsydræ (q.v.). The running of fine sand from one vessel into another was found to afford a still more certain measure, and hence the invention of the Hour-glass (q.v.). King Alfred is said to have observed the lapse of time by noting the gradual shortening of a lighted candle.

It is not very easy to trace to its source the history of the invention to which the modern clock owes its parentage, as there are many vague allusions to horologes from a very early period; but whether these were some form of water-clock or wheel-and-weight clock is uncertain. But there seems little reason to doubt that Gerbert, a distinguished Benedictine monk (afterwards Pope Sylvester II.), made a clock for Magdeburg in 996, which had a weight for motive power; and that weight-clocks began to be used in the monasteries of Europe in the 11th century; though it

is probable that these only struck a bell at certain intervals as a call to prayers, and had no dial to show the time. St Paul's Cathedral had a 'clock-keeper' in 1286, and presumably a clock; and Westminster possessed one about 1290, and Canterbury Cathedral about 1292. An entry in the patent rolls of the eleventh year of Edward II. (1318) proves that Exeter Cathedral had a clock in that year, and St Albans, Glastonbury, Padua, Strasburg, and many other places possessed them in the first half of the 14th century. The St Albans clock was a famous astronomical one made by Richard de Wallingford, who was son of a blacksmith of St Albans, and afterwards became abbot there (1326-34). The clock made for Glastonbury Abbey by Peter Lightfoot, a resident monk (about 1325), was removed in the reign of Henry VIII. to Wells Cathedral, and is now preserved in South Kensington Museum; as is also an old clock from Dover Castle, bearing the date 1348, and the initials R.L. in monogram. The original great clock at Strasburg Cathedral was made in the years 1352-70 (remodelled and reconstructed in 1571-74). A clock much superior to anything preceding it was that made by Henry de Vick (or Wick) for the tower of

Charles V.'s palace at Paris in 1370-79. It was said to be on the bell of this clock that the signal was given for the massacre of St Bartholomew, 1572. By successive improvements clocks have gradually developed into the beautiful pieces of mechanism of the present day. Many curious and interesting specimens, such as that of Strasburg (q.v.) (1594), Lyons Cathedral (1598), St Dunstan's, London (1671; removed to a house in Regent's Park, 1831), and many others, have an historical interest. Many curiosities of mechanism are still constructed in the name of clocks, but generally eccentricity is their only feature. Those interested in the subject will find much information in Wood's *Curiosities of Clocks and Watches* (1866).

The date when portable clocks were first made cannot be determined. They are mentioned in the beginning of the 14th century. The motive power must have been a mainspring instead of a weight. The Society of Antiquaries of England possesses one with the inscription in Bohemian that it was made at Prague by Jacob Zech in 1525. It has a spring as motive power with fusee, and is one of the oldest portable clocks in a perfect state in England.

Illuminated clock dials, to shine at night, were introduced in the first quarter of the 19th century.

Clocks are of many and various kinds—striking and non-striking—turret-clocks big enough to carry hands 6 to 10 feet long and to ring a bell to be heard at 20 miles' distance, the good old-fashioned eight-day clock with its long case, the ornamental drawing-room spring clocks, Dutch clocks, American clocks, and an infinity of others. Technically, those which strike are called *clocks*, and those which do not strike, *timepieces*, irrespective of size. But, however much they may vary in size and appearance, they are all founded on the same principle, and it will

answer our present purpose to illustrate that principle in its more ordinary form of the household clock.

Fig. 1 represents a diagram of a non-striking timepiece. A weight, by turning a barrel, *a*, on which its cord is wound, sets in motion a train of wheels, *b*, *c*, terminating in the crown-wheel or escapement-wheel, *d*. These wheels are set between two plates which are fixed together by four pillars, one at each corner; the pillars are riveted into the back plate, *k*, and fastened with movable pins into the front plate, *k'*. The dial, removed in the fig., is also pinned on to the front plate by four short pillars or feet. The teeth in the pinions and wheels are so arranged in number that, while the crown-wheel revolves in 60 seconds, the centre wheel, *b*, takes an hour to do so. To regulate the speed at which the clock shall move, an arrangement called an escape-



Fig. 1.

ment, *e* (to be afterwards more fully described), communicates by means of its *crutch* (at *f*) with the pendulum, *g*, which is suspended by a spring from the cock at *A*. The arbor of the barrel extends in a square form to the dial at *i*, where it is wound up; a ratchet preventing its unwinding without turning the wheel with it. The hands have a separate train of wheels, called the dial or motion train, between the front plate and the dial. The arbor of the centre wheel, *b*, is produced to the dial, and on it is put the minute-wheel, revolving once an hour, with a long socket on which the minute-hand is fixed. Over this is placed a larger wheel, the hour-wheel, *h*, revolving in twelve hours, which is set in motion by the pinion of a duplicate minute-wheel, *m* (and also seen at *h*, fig. 6). The attachment of the minute-wheel to the centre-wheel arbor is, by means of a spring, enough to ensure the hands being carried round with the clock, but not enough to prevent the hands being turned, when necessary, by hand, without disturbing the interior works.

Striking-clocks have an additional train of wheels with separate weight (or spring) for the striking; it will be described further on.

Spring-clocks—i.e. clocks having a coiled spring as a motive power instead of a falling weight—have an arrangement of barrel and fusee chain similar to that of the watch, to be afterwards described. The spring is used when it is wished to save space, as the necessary fall of a weight requires a case deep enough to hold it, something about 4 feet for an eight-day clock. Their size also necessitates a short pendulum, which, of course, does not indicate seconds.

Previous to the invention of the pendulum, the regulating apparatus was generally as shown in

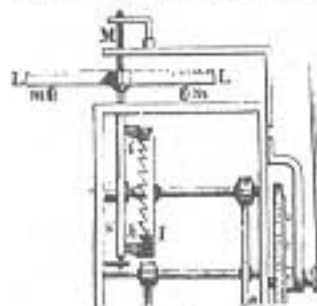


Fig. 2.

fig. 2, which represents part of De Vick's clock already mentioned. The teeth of the escape-wheel, *I*, acting on the two pallets, *A*, *i*, attached to the upright spindle or arbor, *KM*, to which is fixed the balance, *LL*, gave to the latter an alternate or vibrating motion, which was regulated by two small weights, *m*, *m*. The further

these weights were moved from the centre, the more they retarded the movement; and, by means of numerous notches, their position could be shifted till the proper speed was secured. The great epoch in the history of horology was the introduction of the Pendulum (q.v.) as a regulating power. This has generally been attributed to Huygens, a Dutch philosopher, who was undoubtedly the first to bring it into practical use (1657). The fact of the actual invention, however, is obscure, and Sir E. Beckett says: 'The first pendulum clock was made for St Paul's church, in Covent Garden, by Harris, a London clock-maker, in 1621, though the credit of the invention was claimed also by Huygens himself, and by Galileo's son, and Avicenna, and the celebrated Dr Hooke.' In adapting the pendulum to the clocks previously existing Huygens had only to add a new wheel and pinion to the movement, to enable him to place the crown-wheel and spindle in a horizontal instead of a perpendicular position, so that the balance, instead of being horizontal as in De Vick's clock, should be perpendicular and extended downwards, forming a pendulum at one end.

The principle of construction adopted by Huygens, from the peculiar action of the levers and spindle, required a light pendulum and great arcs of oscillation; and it was consequently said that 'Huygens's clock governed the pendulum, whereas the pendulum ought to govern the clock.' About ten years afterwards the celebrated Dr Hooke invented an escapement which enabled a less maintaining power to impel a heavier pendulum. The pendulum, too, making smaller arcs of vibration, was less resisted by the air, and therefore performed its motion with greater regularity. This device is called the *anchor* escapement. It was brought by Hooke before the notice of the Royal Society in 1666; and was practically introduced into the art of clock-making by Clement, a London clock-maker, in 1680. It is the escapement still most usually employed in ordinary English

clocks. Fig. 3 represents the more modern form of the anchor or recoil escapement: *A*, its axis; *BC*, the pallets; and *D*, the escapement-wheel revolving in the direction of the arrow. The connection between the pendulum and escapement may be seen in fig. 1. When the pendulum



Fig. 3.

swings to the right *AC* rises, and a tooth escapes from *C*, while another falls on the outside of *B*, and, owing to the form of the pallet *B*, the train goes back during the remainder of the swing. The same thing occurs on the pendulum's return; the arm *AB* rises, a tooth escapes from *B*, and another falls on the inside of *C* and backs the wheelwork as before. As each of the thirty teeth of the wheel thus acts twice on the pallets, at *B* and again at *C*, it follows that a hand fixed on its arbor will move forward $\frac{1}{2}$ th of a circle with each vibration of the pendulum and mark seconds on the dial. At each contact the onward pressure of the wheel gives an impulse to the pendulum, communicated through the crutch, sufficient to counteract the retarding effects of the resistance of the air and friction, which would otherwise bring it to a standstill. The length of a pendulum oscillating seconds is, for the latitude of London, about 39.14 inches.

The defect of Hooke's escapement is the recoil, and various modifications have been devised to obviate this. The first and most successful was made by George Graham, an English watch-maker, in the beginning of the 18th century, and his improved form is called the *dead-beat* escapement (fig. 4). There the outer surface of *B* and inner surface of *C* are arcs of circles whose centre is *A*, and a little consideration will show that there can be no recoil. This escapement is adopted in time-keepers when great accuracy is required.

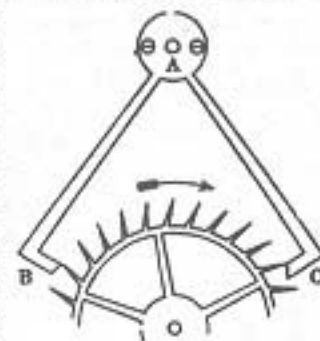


Fig. 4.

Many other escapements for clocks have been devised; but no one seems to have met with general favour except a certain form of *remontoire* or *gravity* escapement. The form of it shown in fig. 5 is called the *double three-legged* escapement, and was invented for the great clock at Westminster, in 1854, by E. B. Denison (afterwards Sir E. Beckett, Q.C.). In this clock the pendulum is 13 feet $\frac{1}{2}$ inch long, to vibrate in two seconds, and its bob weighs 6 cwt. The escapement consists of two gravity impulse pallets, *AB* and *AC*, moving on pivots at *A*. The escape-wheel consists of two three-legged wheels, *abc* and *def*, squared on one arbor a little distance apart, with three lifting

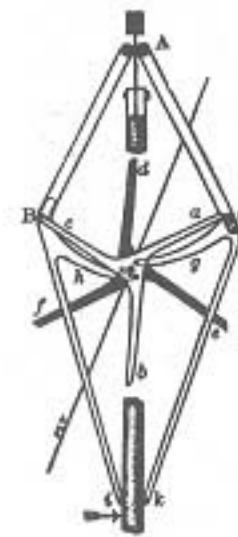


Fig. 5.

pins (or three-leaved pinion) fixed between them. The three pins are shown by the three dots in the centre of the fig. The legs of the wheels are generally arranged alternately as in the fig. The pallets, with their arms *g* and *h*, lie between the wheels; at *C* is a block to lock the legs *abc*, and at *B*, on the other side, and of course acting in the reverse direction, is another to lock the legs *def*. The leg *a* is, in the fig., locked on the block at *C*. The pendulum, part of which is removed to show the escape-wheel, is supposed to be moving in the direction of the arrow, and has received impulse from the falling pallet *AB* at *i*; it is just beginning to touch the other pallet at *k*, which has been kept in position clear of the pendulum by one of the centre pins bearing on the arm *g*. The pendulum before turning again moves the pallet *AC* just enough to allow the leg *a* to escape from the locking-block at *C*; the wheel flies round, impelled by the clock-weight,

till the leg *f* locks on the block at *B*; by the same movement the pin which is seen near the end of the arm *A* pushes the pallet *AB* away from the pendulum, which now gets impulse from the fall of the pallet *AC*. This goes on at each side alternately, the pallets being raised by the clock train, the pendulum only unlocking them. To make the motion go smoothly and prevent jar, a fly is attached to the arbor of the escape-wheel by a spring; it is seen in the figure. As the height to which the pallets are lifted is the same, however unequal the force communicated by the train may be, the arc of vibration of the pendulum remains constant, as the weight of the arm and the distance it falls are always the same.

The gradual perfection of the clock required also improvements in the regulating power which finally resulted in the compensation pendulum (see PENDULUM).

The improvements in the escapement and the pendulum bring the mechanical perfection of the clock, as a time-keeping instrument, to the point which it has attained at the present day. But the art of horology would be incomplete unless there were some standard, independent of individual mechanical contrivances, by which the errors of each may be corrected. This standard is supplied by observatories, and the methods by which time is determined belong to the details of practical astronomy. There are in most parts of the United Kingdom now sufficient opportunities of setting clocks by a communication more or less direct with these establishments. When these are not to be had the sun-dial may still be used with advantage as a means of approximation to the correct time. The time which a clock ought to mark is *mean time*, the definition of which will be found in the articles DAY and TIME. The *mean time* at any place depends on the longitude. Supposing a clock to be set to Greenwich mean time, a clock keeping mean time of any place will be 4 minutes faster for every degree of longitude east of Greenwich, and 4 minutes slower for every degree west. Since the introduction of railways, clocks are usually set within Great Britain to Greenwich mean time. In the United States, where the extent of country makes it unadvisable to use the mean time of one meridian, four standard meridians were adopted in 1883—viz. 75°, 90°, 105°, 120° west of Greenwich. Clocks showing 'Eastern,' 'Central,' 'Mountain,' and 'Pacific' time are therefore respectively five, six, seven, or eight hours slower than Greenwich mean time.

For the more ready transmission of correct time to the public there is at Greenwich Observatory, as well as some others, a ball which is dropped by means of electricity precisely at one o'clock. Several attempts have been made to keep the public clocks of a town in perfect agreement with the mean-time clock in the observatory. One means of effecting this was by an electric connection and a modification of Bain's electric pendulum (1840), by Mr R. L. Jones of Chester (1857), on the suggestion of Mr Hartnup, the astronomer of the Liverpool Observatory. For a description, see ELECTRIC CLOCK. A clock in the castle of Edinburgh, by whose mechanism a gun is fired precisely at one o'clock every day, is controlled by the mean-time clock in the observatory on the Calton Hill.

It is not known when the alarm or when the striking-mechanism of the clock was first applied. The first striking-clock probably announced the hour by a single blow, as they still do in churches to avoid noise. During the 17th century there existed a great taste for striking-clocks, and hence a great variety of them. Several of Tompion's (died 1713) clocks not only struck the quarters on eight bells, but also the hour after each quarter.

The striking part of a clock (see fig. 6, which shows an English striking-clock by Ellicott, taken from the engraving in Moinet's work) is a peculiar and intricate piece of mechanism. The motive power is a weight used in a similar manner to that in the time-keeping train shown in fig. 1. In fig. 6, *a*, *b*, *c*, *d*, *e* are the striking-train; *e* is a fly which acts as a drag to prevent the striking being too rapid. The striking-train is kept in a normal condition of rest by the tumbler or gathering pallet *f*, fixed to the prolonged arbor of the wheel *c*, being caught by the pin at the end of the rack *g*. A few minutes before the hour, a pin on the wheel *h*, of the dial-train, raises the arm, *i*, of the lifter *k*, *l*, which in turn lifts the lever *m*, which has by means of its hook been holding the rack, *g*, fixed. The tail end, *n*, of the rack is then forced by the spring, *o*, against the 'snail' *p*. The snail is attached

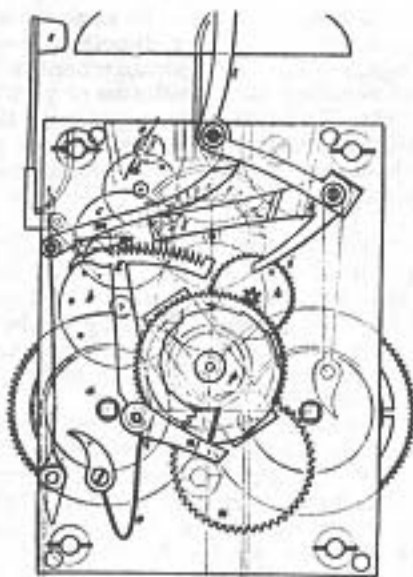


Fig. 6.

to the hour-wheel of the dial-train (see fig. 1), and consequently revolves in twelve hours, and has a step for every hour. The rack, in falling on it, is freed to the extent of a tooth (i.e. a tooth gets past the hook at *m*) for every step of the snail. As shown in the fig., one tooth would be freed, and the result would be that the clock would strike one; when the last step of the snail is reached, twelve would be struck. The result of this movement is that the striking-train moves a little till a pin on the wheel *d* catches on the end of the lifter *l*, which is turned down through a hole in the plate for the purpose. The resulting sound is called 'warning.' Precisely at the hour the pin on the wheel *h* slips past the end, *i*, of the lifter, which falls, relieving the striking-train; the hours are struck on the bell *r*, by the hammer *s*, acted on by the pins on the wheel *b*. As the tumbler attached to the wheel *c* revolves once for every stroke of the bell, it gathers up a notch of the rack at each revolution, until it is stopped by a return to its original position of rest at the pin on the rack *g*. The rack, lever, and lifting-piece are above the front plate, and are pivoted on studs fixed into it. A lever, *t*, moved by a pointer on the dial, throws the striking work out of gear when the clock is required to be silent. In the fig. *u* is an extra wheel for driving a hand to show the days of the month.

Clocks which chime the quarters and half-hours have generally a third train of wheels for the chiming.

In England clocks are principally made in London and Handsworth near Birmingham, though there are many small local makers. Many of the ornamental clocks and timepieces are manufactured in France.

Dutch or wooden clocks were first introduced about the middle of the 17th century. Though made on the same principle as ordinary clocks, their arrangements are much simplified, and their principal parts made of wood and wire, only the actual wheels being brass. They are very cheap, and consequently became very common in lower-class households and kitchens. They are made in the Black Forest in Germany, and, considering their mode of manufacture, are wonderfully accurate as timekeepers when properly taken care of.

They are now rapidly being superseded by American clocks, which, on account of their cheapness, neatness, and portability, have become very popular. Their manufacture is a great industry in the United States, at Waterbury in Connecticut, Brooklyn, New York, and many other places. The wheels and plates are stamped, and very little manual labour is spent on them, every part being interchangeable in similar-sized clocks. Their appearance is too familiar to require a detailed description. To many of these cheap clocks alarms are fitted, which can be set to sound at any hour. See ALARM.

Watches.—The modern perfect watch and chronometer may be said to be the result of a gradual development from the early clock rather than that of any particular invention. The first step was obviously to find some other form of power than the weight; and this was made in the end of the 15th century by the invention of the coiled spring as a motive power, but where, or by whom, is uncertain.

It seems to be taken for granted that Peter Hele, a mechanic of Nuremberg, as early as 1490 made small pocket clocks of steel which showed and struck the hours, and were driven by a coiled spring. These from their oval shape were called Nuremberg eggs. The next step was the invention of the fusee, an arrangement to overcome the weakening of the spring as it became uncoiled. This also is involved in obscurity, though it must have occurred early in the 16th century, as the clock mentioned as made by Jacob Zech in 1525 has that modification. At first a gut cord was used, the chain being a modern invention. The balance used was exactly like that of De Vick's clock (fig. 2), except that the weights on the arms of it were fixed instead of hanging. The next step of any consequence was the invention of the balance-spring by Dr Hooke in 1658-60, which was the foundation of all the varied improvements resulting in the almost perfect chronometer compensation-balance of the present day.

Although watches were introduced into England in Henry VIII's time, they did not come into general use till the reign of Elizabeth, and then their cost confined them to the wealthy. At first they were very large, on account of their striking part; and their cases, without glass, were pierced with elaborate open work to let out the sound of the bell. When the striking work was dispensed with, they of course became much smaller, and gradually drifted into being ornamental rather than useful. They were richly ornamented with pictures in enamel, set in the heads of walking-sticks, in bracelets, in finger-rings, and enriched with the most costly jewels. They were encased in crystal and in imitation skulls, and in fact became subject to all the vicissitudes of fashion, through which it would be needless for us to follow them. The curious will find much entertaining matter in Wood's work already referred to. Previous to the invention of the balance-spring, watches (as also clocks) had only one hand, which showed the hours; but after that event the greater power of regulating the motion led to the introduction of extra wheels to carry minute, and finally seconds, hands.

The watch is essentially a miniature edition of the ordinary spring-clock, except in two points—viz. that it has a balance-spring instead of a short pendulum, and that, as the escapement-wheel revolves in about six seconds, an extra wheel revolving in a minute is introduced to carry the seconds hand.

The train of an ordinary verge watch is shown in fig. 7: *a* is the barrel enclosing the mainspring and turning, by means of the fusee chain *b*, the fusee and great wheel *c*, and, through the pinions and wheels *d*, *e*, *f*, the escape-wheel *g*. The hands

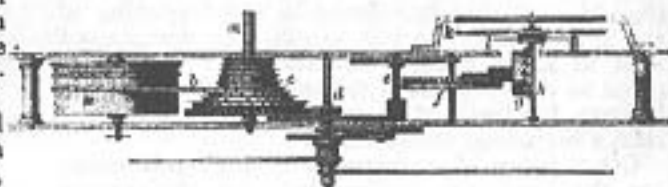


Fig. 7.

or motion train are exactly as described for clocks, and are similarly carried by the elongated arbor of the centre-wheel *d*. As will be seen in the fig., the fusee is of a peculiar shape. The reason is as follows: When the chain, which is fixed at the broadest part of the fusee, is fully wound up, it goes from the narrow part to the barrel where the other end is fixed, and of course the spring is also fully wound. At this point the spring is strongest; and, pulling upon the narrow end of the fusee, has the least leverage. As it gradually unwinds, and at the same time becomes weaker, the leverage, owing to the shape of the fusee, becomes in exactly the same ratio greater, and thus the power on the machinery is equalised till the whole chain is unwound. The spring is wound up by the squared arbor, *m*, of the fusee through an opening in the inside case; the arbor of the spring-barrel being of course fixed. An ingenious stop arrangement prevents the possibility of damage by over-winding. The mainspring is a thin ribbon of finely tempered steel (fig. 8). The inner end is hooked on to a catch on the arbor of the barrel round which it is coiled, and the outer end to a catch on the inside of the rim of the barrel. In the American watches, now so



Fig. 8.

can watches, now so

common, the fusee is

dispensed with, and the great wheel is on the barrel and directly gives the motion. In recent years this form is also used in almost all keyless watches. The verge escapement shown in fig. 7 is exactly the same as that shown in De Vick's clock (fig. 2). Two pallets, *A*, *i*, moved alternately in opposite directions by the teeth of the escapement-wheel, cause a vibrating motion in the balance *k*, which is steadied and regulated by the balance-spring *l*. The balance and spring are shown in plan in fig. 9: *a* is the balance and *b* the spring, which is arranged spirally. The inner end is fixed to the staff of the balance, the outer to a stud *c*, fixed to the watch-plate. Its beautifully delicate motion may be observed in any watch, as all watches have the spiral spring except chronometers, which have a cylindrically coiled spring instead. The length of the balance-spring



Fig. 9.

in proportion to the weight of the balance is an important factor in regularity of motion, and for minute adjustment an instrument, *d*, *e*, called a *regulator* is attached to it. Two curb-pins at *d* enclose the outer coil of the spring, and, in the case of the watch going fast, a movement to the left lengthens the spring and retards the speed in proportion. For too slow a motion a movement to the right will shorten the spring and quicken it.

The principle involved in the clock-pendulum and watch-balance alike is that by their regularity of movement they shall keep the mechanism from going either too fast or too slow, and that in return the mechanism shall give repeated impulses sufficient to keep them perpetually in motion.

As the vertical or verge escapement,

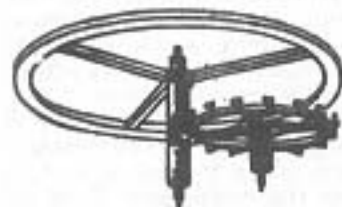


Fig. 10.

owing to the recoil of the escape-wheel and other causes, is not to be depended on for very great accuracy, attempts were immediately made after the invention of the balance-spring

to devise some form of escapement which would give better results. Hooke, Huygens, Hauteville, and Tompion introduced improvements, but the first to succeed was made by George Graham, the inventor of the dead-beat escapement in clocks.

This is called the *horizontal* or *cylinder* escapement (fig. 10). It was introduced in the beginning of the 18th century, and it is still the escapement used in many foreign watches. The impulse is given to a hollow cut in the cylindrical axis of the balance by teeth of a peculiar form projecting from a horizontal crown-wheel.

Other forms of escapement in high estimation are the *lever*, the *duplex*, and the *chronometer* 'spring-detent' escapement. The lever escapement (invented about 1770 by Thomas Mudge) is the dead-beat escapement (see fig. 4) adapted to the altered conditions of a watch. Fig. 11 shows the form used in most modern English watches. The pallets, *P*, *P*, are fixed to a lever, *A* (pivoted at *F*), and there is an impulse pin, *B* (usually a piece of ruby), set in a small disc, *C* (called the roller), on the axis of the balance.

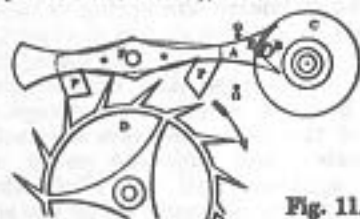


Fig. 11.

The ruby pin works into a notch at the end of the lever, and the pin and notch are so adjusted that when a tooth of the escape-wheel *D* leaves the pallet the pin slips out of the notch, and the balance is detached from the lever during the remainder of its swing; whence the name *detached* lever escapement, originally applied to this arrangement. On the balance returning, the pin again enters the notch, moving the lever just enough to allow the tooth next in order to escape from the dead face of the pallet on to the impulse face; then the escape-wheel acts upon the lever and balance; the tooth escapes, and another drops upon the dead

face of the pallet, the pin at the same time passing out of the notch in the other direction, leaving the balance again free. This arrangement is found to give great accuracy and steadiness of performance. A safety pin, *E*, on the lever, prevents the wheel being unlocked, except when the impulse-pin is in the notch of the lever. Two *banking-pins*, *GG*, keep the motion of the lever within the desired limits.

In the duplex escapement (invented about 1780) the escape-wheel has two sets of teeth, hence the name. One set, something like the lever-wheel (fig. 11), lock the wheel by pressing on the balance staff, and the other, standing up from the side of the rim of the wheel, give impulse to the balance. It is rarely used now.

The chronometer spring-detent escapement was invented in principle by Le Roy about 1765, and perfected by Earnshaw (who also invented the cylindrical balance-spring) and Arnold about 1780. It is shown in fig. 12: *a* is the escape-wheel, which has fifteen teeth; *b*, the impulse-roller, fixed on the same staff as the balance; *c*, the impulse-pallet; *d*, discharge-pallet; *e*, locking-pallet—all the pallets are of ruby or sapphire; *f*, the blade of the detent fixed at *k* by its spring *g*; and *h*, the gold-spring. In the fig. a tooth of the escape-wheel is caught on the locking-pallet; the discharge-pallet (carried round by the roller in the direction of the arrow), by pressing on the end of the gold-spring, which in turn presses on the horn of the detent *i*, bends the detent enough to allow the tooth to escape from the pallet. The escape-wheel, being released, overtakes the impulse-pallet and drives it on till their paths diverge and they separate. The wheel is again brought to a

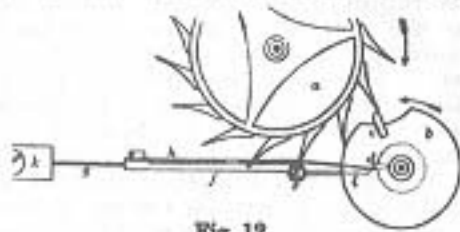


Fig. 12.

stand by the locking-pallet of the detent, which, on being released by the discharge-pallet, has sprung back to its original position. The roller, having made its vibration, is brought back by the spring. In the return the discharge-pallet forces itself past the end of the gold-spring, the impulse-pallet clears the teeth of the escape-wheel, and the balance goes on till the momentum is exhausted, when the spring induces another vibration, the wheel is again unlocked, and the impulse-pallet gets another blow. By receiving impulse in one direction and unlocking at every alternate vibration only, the chronometer-balance is more thoroughly detached than any other. It is very delicate, however, and, though the most perfect known, it cannot stand rough usage, and is not so suitable for ordinary pocket-watches as a good lever. At sea the chronometer is hung in Gimbals (q.v.), so as to be always horizontal whatever the motion of the vessel.

In watches, even more than in clocks, variations of temperature, unless provided for, produce variations in the rate of going. A rise in the temperature makes the balance expand, and therefore augments its moment of inertia. It diminishes the elasticity of the spring; and the time of vibration of the balance, which depends upon the moment of inertia directly, and upon the elastic force of the spring inversely, is increased—the watch, that is, goes more slowly. A fall in the temperature is attended by opposite results, the watch going more rapidly than before. Compensation can obviously be made in either of two ways—by an expedient for shortening the effective length of the balance-spring as the temperature rises, so as to increase the elastic force of the spring; or by an expedient for diminishing the moment of inertia

of the balance as the temperature rises, so as to correspond to the diminution of the force of the spring. The first method was that made use of by John Harrison (q.v.) in his chronometer, and it depended on a laminated bar of brass and steel fixed at one end, called a *compensation curb*; the free end carries two curb pins, which embrace the balance-spring, and, as the bar shrinks and expands, regulate the length of the spring. It is never used now. An adaptation of the other method, invented in 1782 by John Arnold, and improved by Thomas Earnshaw, is that which is always employed now. Fig. 13 shows the

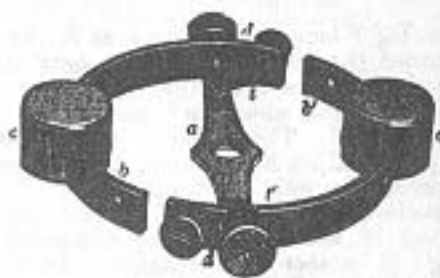


Fig. 13.

form employed for marine chronometers, and fig. 14 that for pocket chronometers and watches: *t*, *a*, *t'* (fig. 13) is the main bar of the balance; and *t*, *b*, *t'*, *b'* are two compound bars, of which the outer part is of brass and the inner part of steel, carrying weights, *c*, *c'*, whose position may be shifted to or from the fixed end, according as the compensation is found on trial to be less or more than is desired. Brass expands more with heat and contracts more with cold than steel; consequently, as the temperature rises the bars with their weights, being fixed at one end to the main bar, bend inwards at the free end, and so the moment of inertia of the balance is diminished; as it falls they bend outwards, and the moment of inertia is increased; and of course the diminution or the increase must be made exactly to correspond to the diminution or increase in the force of the spring. The screws, *d*, *d'*, fitted to the fixed end of each of the compound bars are used for bringing the chronometer to time; sometimes the smaller ones are dispensed with. In fig. 14 the principle is the same: *a*, *a*, *a* are the time screws (equally distributed in the watch-balance); the others are for compensation, and their positions may be shifted or larger ones substituted if necessary.

The modern marine chronometer is just a large watch fitted with all the contrivances which experience has shown to be conducive to accurate time-keeping—e.g. the cylindrical balance-spring, the detached spring-detent escapement, and the compensation-balance. Harrison's chronometer, mentioned above, was the first, and was completed after many years of study in 1736. For a description, see *British Horological Journal*, vol. xx. page 120. After many trials and improvements, and two test voyages to America, undertaken for the satisfaction of the commissioners, the last of which was completed on the 18th September 1764, the reward of £20,000, which had been offered by government for the best time-keeper for ascertaining the longitude at sea, was finally awarded to him. Harrison made many other inventions and improvements in clocks and watches, including his maintaining spring to the fusee, to keep the works going while being wound; a form of remontoire escapement, &c.

Somewhat later than this several excellent chronometers were produced in France by Berthoud and Le Roy, to the latter of whom was awarded the prize by the Académie Royale des Sciences. Progress was still made in England by Mudge, Arnold, and Earnshaw, to whom prizes were awarded by the Board of Longitude. The subsequent progress of watch-making has been chiefly directed to the construction of pocket-watches on the principle of marine chronometers, and such accuracy has been obtained that the average error is reduced to one second a day.

The compensation of an ordinary balance chronometer cannot be made perfectly accurate for all degrees of temperature, but only for two points. The explanation of this lies in the fact that, while the variations of elastic force in the spring go on uniformly in proportion to the rise or fall of the temperature, the inertia of the balance varies, not inversely as the distance of its weights from the centre, but inversely as the *square* of the distance of the centre of gyration from the centre of motion.

The particular points in the case of any chronometer are matter of adjustment. For instance,

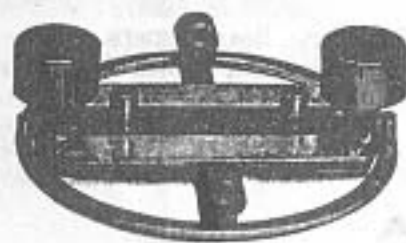


Fig. 15.

one chronometer may be made to go accurately in a temperature of

40°, and also in a temperature of 80°, at other temperatures being not so accurate; another chronometer to go accurately at a temperature of 20° and 60°. It is manifest that the former would be adapted to voyages in a warmer, the latter to voyages in a colder climate. To more fully adjust the compensation certain pieces are fixed to the balance to act in heat or in cold, and this is called auxiliary compensation, and there are at least two or three balances invented of recent years, one of which is shown in fig. 15, which are practically self-adjusting for the ordinary range of temperatures to which marine chronometers are subjected. The solution of the problem seems to be in setting the laminae flat instead of vertical, and making the bar also bimetallic.

Apparatus for testing chronometers have been long in use in the observatories at Greenwich and Liverpool. In the latter there is now an extensive apparatus for this purpose, devised by the ingenious astronomer, Mr Hartnup. In a room which is isolated from noise and changes of temperature the chronometers are arranged on a frame under a glass case, so contrived that they may be subjected in turn to any given degree of temperature. The rate of each under the different temperatures is observed and noted, and the chronometers registered accordingly.

A large proportion of modern watches are made to wind and to set the hands from the pendant. Fig. 16 shows the form of keyless work chiefly employed in English non-fusee watches. The chief part is the three wheels working in the rocking-bar *ab*, one of which gears with the winding-wheel, *d*, of the barrel when the rocking-bar, which is capable of a little motion, is in its normal place, as in the fig. A contrate wheel is fixed on the end of the winding-button *c*, and by its means,



Fig. 16.

when the button is turned, the train is set in motion and the barrel wound. When the hands are required to be set, a push-piece in the case bearing on the end, *b*, of the rocking-bar is pressed by the finger, taking the rocking-bar wheels out of gear with the winding, and putting them in gear with the hand-wheels at *e*. The hands

may then be turned by the winding button, and, the push-piece being let go, the train returns to its normal position. The use of the fusee being attended with some amount of complication in the keyless mechanism, it is usually dispensed with on this account, and one of the most modern arrangements in an English keyless watch is shown in fig. 17. The barrel, *a*, is here made to occupy all the height between the pillar (or lower) plate and the top limit of the movement, and all the space between the centre pinion and the balance cock, in order to get a long, thin main-spring; the advantage of which is that there is an abundance of

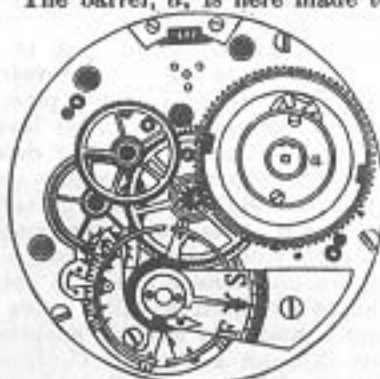


Fig. 17.

power (much more than is required for a day's going), and only a portion of the spring is used for the ordinary winding for twenty-four hours. This practically insures an adjustment of the motive power as nearly equal to that obtained by the use of the fusee as it is possible to arrive at.

Repeating watches were first made about 1676, the invention being claimed by Daniel Quare, Edward Barlow, and Tompion. They have a striking arrangement very much on the principle of the striking-clock, and on compressing a spring they at any time strike the hours and quarters, and in some cases the minutes. They are very expensive and liable to go out of repair, and repairs are costly. They have nearly gone out of use. For stop-second arrangements to record swift passing events, see CHRONOGRAPH.

In England watches are mostly made at Preston, Liverpool, Coventry, and at Clerkenwell, London, where the division of labour principle is carried out in an extreme degree—many small factories making, for instance, only balances, others springs, others cases, others hands, &c., only that small number who put the works together seeing the complete watch. At Kew Observatory there are arrangements for testing watches, and granting certificates if satisfactory, on payment of a fee. In the United States the manufacture of watches, like that of clocks, is carried on in a much more wholesale manner; the wheels and plates being stamped by machinery, every similar part being exactly alike and interchangeable; and on account of the economy of manual labour, they can be turned out marvellously cheap. Generally the large clock-factories also manufacture watches.

Horse-radish (*Cochlearia Armoracia*), a perennial herbaceous plant, belonging to the natural order Cruciferae and to the same genus as scurvy-grass. It possesses the same antiscorbutic properties as the latter, but is better known popularly on account of its use as a condiment with roast-beef. It is highly stimulant, exciting the stomach



Roots of Horse-radish (a) and Monkshood (b).

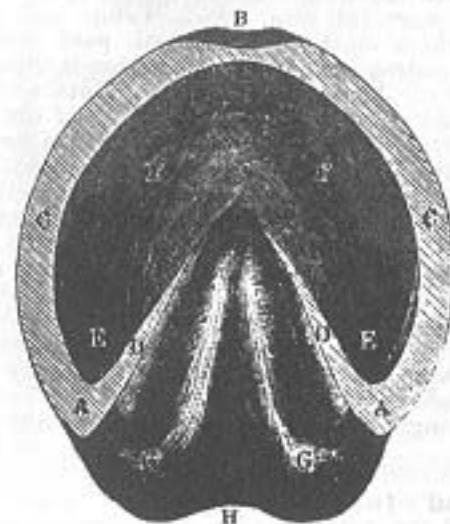
and promoting the secretions, particularly that of urine. Its virtues depend upon a volatile oil similar to oil of mustard. The oil contains about 30 per cent. of sulphur to its other elements, and is recognised as one of the most powerful antiscorbutics known. Horse-radish is a native of south-eastern Europe, has long been cultivated in British gardens, and is naturalised in some parts of England and Ireland. For its perfect cultivation it requires very deeply-worked soil, from which it is very difficult to eradicate, as the smallest bit of root not removed will emit a bud. Cases of fatal poisoning have several times occurred through the ignorant mistaking

hood bears its flowers freely in handsome racemes, at the extremities of usually simple or unbranched stems; the colour is deep blue, and the unopened flower strongly resembles a helmet or hood.

Horse-radish Tree. See BEN (OIL OF).

Horseshoeing. In olden times horses generally went unshod, as they now do in many eastern countries; but our macadamised roads and paved streets, fast paces and heavy loads, would speedily wear away the stoutest hoofs, and a rim of iron has accordingly been long in use as a protection. In style and pattern the horse's shoe varies almost as much as his master's boot, and like it, when badly made or unskillfully fitted, produces serious inconvenience, and even leads to accidents and diseases. When the feet are strong and properly managed nothing is better than a plain shoe of tolerably uniform breadth and thickness, carefully fashioned to the shape of the foot. But many good authorities prefer what is called a seated shoe, which has a level part for the crust to

rest upon, and within that the inner half of the shoe towards the sole surface is bevelled off. This seated shoe is thus wider than the plain shoe, and hence affords greater protection for a weak or flat sole. For faulty or diseased feet special forms of shoes are made. In all healthy feet the shoe should be fitted to the foot, and not, as is commonly done, the foot cut to fit the shoe. Another frequent error must be avoided—keeping the shoe short and spare at the heels. For roadsters the toe of the fore-shoes should be slightly turned up, which greatly obviates tripping. The hind-shoes are generally thickened and sometimes turned down at the heels. The number of nails required must vary somewhat with the weight of the shoe and the soundness of the horn; five is the minimum, nine the maximum. It is important, however, that the shoes be firmly held on by as few nails as possible. In a saddle-horse with sound feet three on the outside and two on the inside should suffice to hold a well-fitted shoe. Horses for heavy draught



A sound Fore-foot prepared for the Shoe:

A, A, the heels of the crust; B, the toe cut out to receive the clip; C, C, the quarters of the crust; D, D, the bars as they should be left, with the full frog between them; E, E, the angles between the heels and bars, where corns appear; F, F, the concave surface of the toe; G, G, the bulbous heels; H, the cleft.

are generally shod in Scotland with tips and heels, which afford increased firmness of tread and greater power, especially when dragging heavy loads. To preserve the foot in a sound state the shoes should be removed every month. When the shoe is carefully taken off, the wall-surface on which it has rested should be rasped, to remove any ragged edges and any portions of adhering nails. Having for a month been protected from the wear to which the exposed portions of the foot are subjected, it will probably have grown considerably, and in a stout hoof will require to be cut down with the drawing-knife, especially towards the toe. Except in very strong feet and in farm-horses working on soft land, the surface of the sole uncovered by the shoe seldom requires to be cut. It is the natural protection of the internal delicate parts, and must be preferable to the leather and pads often artificially substituted for it. The bars must likewise remain untouched, for they are of great service in supporting weight; whilst the tough, elastic frog must be scrupulously preserved from the destructive attacks of the knife, and allowed uninjured to fulfil its functions as an insensible pad, obviating concussion, and supporting weight.

When the shoe is put on and the nails well driven home, they should be broken off about an eighth or even a sixteenth of an inch from the crust, and hammered well down into it. This obviously gives the shoe a much firmer hold than the usual practice of twisting off the projecting nail close to the crust, and afterwards rasping down any asperities that still remain. When the shoe is firmly clinched the rasp may be very lightly run round the lower margin of the crust just where it meets the shoe, to smooth down any irregularities; but all further use of the rasp must be interdicted. The clinched nails if touched will only have their firm hold weakened; nor must the upper portions of the crust, which blacksmiths are so fond of turning out rasped and whitened, be thus senselessly deprived of those external unctuous secretions which render the unrased foot so tough and sound and so free from sanderacks. The hoof cannot be too dry and tough. From time to time various attempts have been made to fix shoes to horses' feet without nails; and a shoe has been invented, which is said to have answered the purpose; but in the opinion of many the system is still immature, and requires to be more extensively tested.

Hotbed, a bed of fermenting vegetable matter, usually surmounted by a glazed frame, employed in gardening for cultivating melons and cucumbers, the rearing of tender annuals, propagating stove and greenhouse plants by cuttings, seeds, or grafting, forcing flowers, &c. It is an inexpensive means for obtaining a high temperature in a limited atmosphere, accompanied with genial humidity charged with nutritious gases, which is very beneficial to plants. Formerly it was an indispensable adjunct to the garden, but the almost universal employment of hot water as a heating agent for horticultural purposes has latterly greatly circumscribed its use. The materials used in making hotbeds are stable-dung, leaves—those of the oak and beech, being especially suitable, are frequently mixed with the dung—tanners' bark, spent hops, and the waste of jute, cotton, hemp, and flax, all of which must be allowed to pass through the first violent stages of fermentation in order to eliminate the deleterious gases they contain before being built up into the bed. The size of the bed is regulated by the degree of heat required for the purpose in view. A bed of stable-dung with or without leaves intermixed, four feet thick, will for some time after it is built maintain a temperature of from 75° to 90°, which is sufficient for most purposes. As the fermentation declines the bed cools down, but heat is again readily increased by adding fresh material to the sides of it. The bed should be made a few inches wider and longer than the frame that is to be placed upon it, and from 6 to 9 inches higher at the back than the front to secure a better angle for light. See also PLANT-HOUSE.

Hound's-tongue (*Cynoglossum*), a genus of plants of the natural order Boraginæ, of which there are many species, all of a coarse appearance, with small flowers. The Common Hound's-tongue (*C. officinale*) is a native of Europe, Asia, Africa, and North America; not uncommon in some parts of Britain, especially near the sea-coast. It has soft downy leaves, of a dull green colour, purplish-red flowers, and a stem about two feet high.



Hound's-tongue (*Cynoglossum officinale*).

Its odour is very disagreeable. The root was formerly administered in scrofula, dysentery, &c., and is said to be anodyne. It is also one of the pretended specifics for serpent-bites and hydrophobia.

House-fly (*Musca domestica*), perhaps the most familiar and widely distributed dipterous insect. Adults are to be seen the whole year round, though naturally most numerous in summer. They feed indiscriminately on whatever they can suck up through their fleshy proboscis or scrape off with their other mouth parts. The females lay their eggs in groups, about eight days after pairing, and the whole development occupies about a month. The eggs are deposited in decaying organic matter, in dung, or in any filth, and the larvæ are hatched in a day, or even less if the weather be warm. These larvæ are smooth, naked maggots, without legs or distinct head, with small hooklets at the mouth, and a length of about one-third of an inch. They feed on organic debris, move by contracting the abdomen, and grow for about a fortnight. Then they

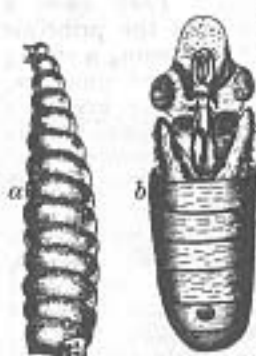


Fig. 1.
a, larva of house-fly, with breathing pores at tail (lower) end; b, young fly emerging from pupa sheath.

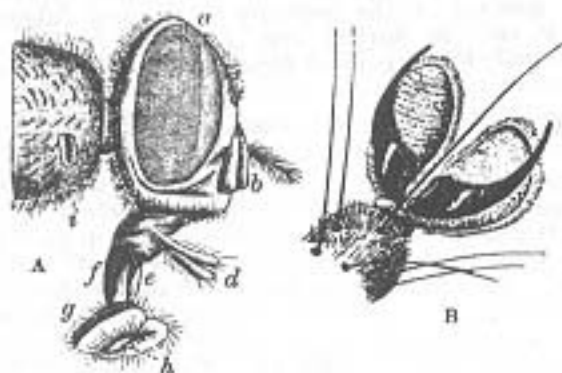


Fig. 2.
A, head of house-fly: a, compound eye; b, antenna; d, maxillary palps; e, f, proboscis; g, labellæ, lips of proboscis; h, opening into proboscis; i, thorax, with breathing pore (after Von Hayek). B, end of a fly's foot highly magnified, showing long hairs, two terminal claws, and two membranous adhesive pads.

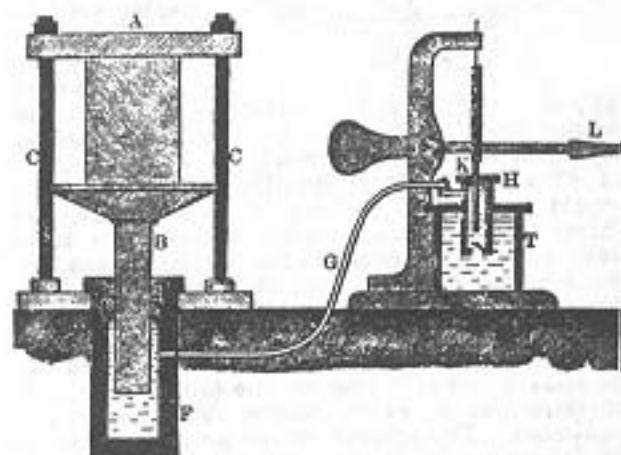
seek some dry resting-place, undergo pupation, and finally in another fortnight become winged insects.

Many parts of the house-fly, such as the sucking proboscis, or the hair-covered discs of the feet by which the insects adhere to the window-pane, well deserve the attention they generally get from those who use the microscope. Though house-flies do not bite, they are often extremely troublesome. Expedients for killing them off require no advertisement. It is more important to notice that house-flies are probably sometimes responsible for disseminating disease-germs.

Hydrates are compounds of water with elements or with other compounds. The term *hydroxide* is one which is sometimes used as a synonym of *hydrate*, and indeed it may be said that we have no certain means of distinguishing the one from the other. The distinction between the two is that in the hydrate the water is supposed to be present as water, and without any rearrangement of the molecules, while in the hydroxide the water is considered to have lost its identity, its constituent atoms having entered into new combinations. As a typical example of a hydrate we may instance crystallised sulphate of copper, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, which contains the water so loosely combined that it is driven off by prolonged heating, and the white anhydrous sulphate, CuSO_4 , is produced. Here the water is apparently present as water, and necessary to the crystalline form, and is therefore called water of crystallisation. When nitric anhydride, N_2O_5 , unites with water it forms nitric acid, $\text{N}_2\text{O}_5 \cdot \text{H}_2\text{O}$ or HNO_3 , but this is not regarded as a hydrate, because the nitric acid cannot lose the water without also losing its characteristic properties. The whole question is full of difficulties, and is at present quite theoretical; different chemists using the terms above mentioned in different senses.

Hydraulic Mortar. See CEMENTS.

Hydraulic Press, often called Bramah's press, from the inventor, Joseph Bramah (q.v.), depends for its action on the principle that a pressure exerted on any part of the surface of liquid is transmitted undiminished and equally



Hydraulic Press.

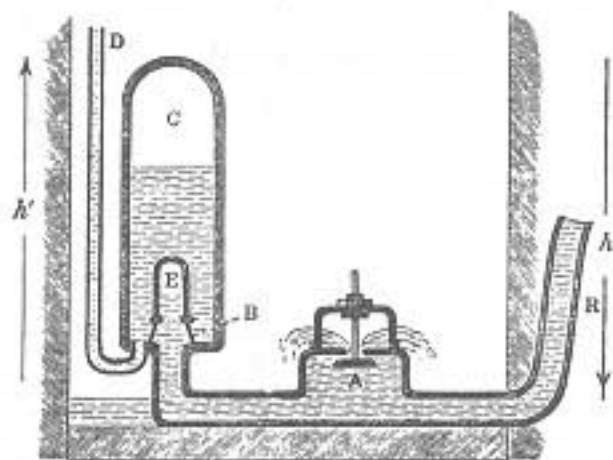
in all directions through the mass (see HYDROSTATICS). The annexed figure represents the essential parts of the machine, minor details of construction being omitted. F is a strong cast-iron or cast-steel cylinder, open at the top; B is a plunger or ram which fits watertight into the cylinder; to prevent leakage a leather ring U-shaped in section is placed in the cavity c; any water trying to leak out forces the two sides of this ring hard against the piston and the side of the cavity, and the greater the pressure the tighter it keeps. This form of packing is now often replaced by an ordinary stuffing-box filled with hemp packing. A pipe, G, leads from the cylinder to a force-pump, H. By means of this pump water can be forced from the tank, T, through the pipe G into the cylinder, thus pushing the plunger or ram, B, upwards. The ram carries on its top a platten or table, on which the bales, &c., to be pressed are placed; the rising of the platten presses them against the entablature or upper plate, A, which is held in position by the columns C. The bale can thus be squeezed to any extent desired.

The power of the press is readily calculated; let the diameters of the pump-plunger, K, and ram, B, be d and D inches respectively, then any downward pressure on K becomes an upward pressure on B magnified $\frac{D^2}{d^2}$ times. Suppose, for instance, that the pressure on K was 500 pounds, and that the diameters are 1 and 10 inches respectively, then the upward thrust would be $500 \times \frac{10^2}{1^2} = 50,000$ pounds;

very enormous pressures are therefore readily obtained, and in consequence of the slow motion there is extremely little waste of power in friction. It is thus a very efficient mechanism. The pump can either be a hand-pump worked by a lever, L, as in sketch, or it may be worked by a steam-engine, as is the case in the modern powerful presses. The enormous multiplying power of this contrivance has led to its most extensive use; for example, compressing cotton and wool bales, &c., expressing oils, bending iron plates and bars, lifting heavy weights (lifts and hoists), raising into position bridge-girders (hydraulic jacks), &c. Presses of enormous power are now superseding the huge steam-hammers in large steelworks, obviating the unpleasant vibrations and ensuring sounder metal.

Hydraulic Ram, a simple and conveniently applied mechanism, by which the energy of water falling from a height, A, can be made available to force a portion of itself to a greater height, A'. There is a supply-reservoir, fed, say by a spring, from which a strong pipe, R, conducts the water to the ram at a lower level. The ram has two valves, one, A, opening downwards and inwards, the other, B, opening upwards and outwards; the weight of these valves is such that when the water is at rest its normal pressure is unable to keep them from falling, so that in this condition A would be open and B shut. A cottar on the rod of A keeps it from opening more than a certain amount, and this can be adjusted; the valve B opens into an air-vessel, C, from the bottom of which the delivery pipe, D, leads away. The action is as follows: the water flows from the reservoir

through the pipe R, and rushes out through the now open valve A away to the waste-pipe; in doing so it acquires considerable velocity, and its pressure therefore on the under side of the valve A increases, and finally becomes great enough to close it. The flow of the water being thus suddenly checked, produces a great reaction, and by its momentum opens the valve B, and forces a portion of the water into the air-vessel C; the energy being expended, the pressure falls again, B closes, and A opens once more, enabling the water to rush out to the waste-pipe, and so the whole operation is repeated. The two valves thus alternately open and close, and water is delivered each time into the air-chamber, C, the air in which being compressed acts as an air-cushion, keeping up a constant delivery through the pipe D.



Section of Hydraulic Ram.

The small air-vessel, E, is for diminishing the shocks, and has a small relief valve in it to admit air when necessary; it is self-acting. The hydraulic ram was an invention of Montgolfier (1797), but has been greatly improved; its mechanical efficiency is good, and for raising small quantities of water, such as are necessary for the supply of single houses, farm-

Hydrides. This term is applied both to combinations of hydrogen with metals, and to similar combinations with organic or compound radicals. Hydrogen forms hydrides with a number of the metals, as, for instance, arsenic, antimony, copper, and potassium. The first two of these are the well-known gases, arseniuretted hydrogen, AsH_3 , and antimoniuretted hydrogen, SbH_3 . In the case of organic radicals, the hydride of ethyl, $\text{C}_2\text{H}_5\text{H}$, for instance, was at one time supposed to be a different substance from dimethyl, CH_3CH_3 , but these were eventually proved to be identical, so that the term hydride, in this sense, is now obsolete.

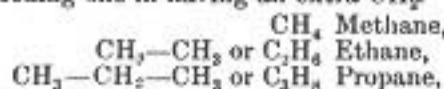
Hydrobromic Acid, (1) gas, HBr , invisible, pungent, acid reaction, fumes in moist air, liquid at -69°C ., solid at -100°C .; prepared from a bromide plus phosphoric acid, or phosphorus tribromide plus water. (2) Aqueous solution, analogous to commercial hydrochloric acid, is weakened by boiling until HBr sinks to 47 per cent., then distils unchanged. See BROMINE.

Hydrocarbons belong to the department of organic chemistry, and may be shortly defined as compounds of carbon and hydrogen, and nothing else. Despite their apparently simple nature, they are frequently very complex, and exist in such numbers as to bewilder the beginner in chemical study. Fortunately, they can be gathered into groups, each having distinctive characters, and the members of which are closely related to each other. The chief of these are the Paraffins, the Olefines, the Acetylenes, the Benzene (q.v.) series, and the Anthracene (q.v.) group.

The *Paraffins* are found in natural petroleum as well as in the products of the destructive distillation of coal, and are known as *saturated hydrocarbons*. By this is meant that the carbon present is already saturated (so to speak) with hydrogen, and has no tendency to unite with other elements or molecules. Graphically, carbon may be represented as C —i.e. with four arms, each one of which is

capable of being united to one atom of hydrogen; and when all four arms are so united, a *paraffin* is produced; thus, $\text{H}-\text{C}-\text{H}$. But, instead of the

single atom of hydrogen, one arm (or all the arms) may be engaged by such a group as CH_3 , so that we get another paraffin, CH_3-CH_3 . Thus we go on forming a series, each member of which differs from the preceding one in having an extra CH_2 . Thus:



and so on indefinitely. It will, however, be noticed that when we pass to a higher member than propane, by replacing an atom of hydrogen by CH_3 , we may do so in two ways, according as the atom replaced is in the CH_3 group at either end, or the CH_2 group in the centre. The result is that two hydrocarbons are possible—viz. $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_3$, and also $\text{CH}_3-\text{CH}(\text{CH}_3)-\text{CH}_3$. In like manner,

as we proceed further, wider scope is given to us, the result being that when Tridecane, $\text{C}_{13}\text{H}_{28}$, is reached, it is theoretically possible to recognise 802 such bodies, all having the same percentage composition, but differing more or less in characters. Many of these isomers are already known. The paraffins are characterised by their indifference to chemical action, being unacted on by caustic potash, sulphuric or nitric acid. The general formula of the paraffins is $\text{C}_n\text{H}_{2n+2}$, where n represents the number of atoms in the formula.

The *Olefines*, C_nH_{2n} .—The chief of these are Ethylene, C_2H_4 , Propylene, C_3H_6 , Butylene, C_4H_8 , Amylene, C_5H_{10} , &c.; and it will be observed that in all of them the percentage composition is identical, and that each member differs from the lower one by the addition of CH_2 . When acted on by chlorine, bromine, or iodine they readily form oily liquids, such as Dutch liquid, and, generally speaking, they markedly differ from the paraffins in the readiness with which they unite with other bodies.

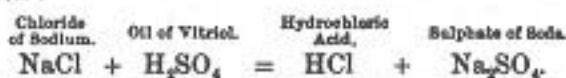
Hydrocharides, or HYDROCHARIDACEÆ. See ANACHARIS, and VALLISNERIA.

Hydrochloric Acid (sym. HCl ; equiv. 36.5) is one of the most important compounds in inorganic chemistry. If the two gases which enter into its composition (hydrogen and chlorine) be mixed in equal volumes they will remain without action upon each other if kept in the dark; but as soon as they are brought into direct sunlight they unite with a loud explosion, and hydrochloric acid gas is the result. The principal characters of this gas are that it is colourless, intensely acid, irrespirable, and even when largely diluted is very irritating to the lungs and eyes, and very injurious to vegetation; that it is heavier than air (its specific gravity being 1.2474, air being taken at 1.000); that it can be condensed into a colourless liquid; that it is very soluble in water, and that it is neither combustible nor a supporter of combustion. When allowed to escape into the air it produces white fumes by condensing the atmospheric moisture. If the air be previously dried no such fumes are apparent.

The solutions of this gas in water form the acid which was first known as *Spirit of Salt*, then as *Muriatic Acid*, and which is now termed *Hydrochloric* or *Chlorhydric Acid*. A saturated watery solution of this gas at 40° (4.4°C .) has a specific gravity of 1.21, and consists of 1 equivalent of the gas dissolved in 3 equivalents of water. It forms a colourless, fuming liquid, which acts as a caustic. On heating it the gas is evolved abundantly until the temperature reaches 230° (110°C .), when there distils over a diluted solution, having a specific gravity of 1.1, and consisting of 1 equivalent of the gas and 8 equivalents of water. It is to these solutions of hydrochloric acid that the term *Hydrochloric acid* is far more commonly applied than to the gas itself. They possess the ordinary characters of an energetic acid, and neutralise the strongest bases. The neutralisation is, however, not in consequence of the acid combining with the oxide, but is due to the simultaneous decomposition of the acid and of the oxide, water and a metallic chloride being formed. If M represents the metal the reaction is expressed by the equation $\text{M}_2\text{O} + \text{HCl} = \text{MCl} + \text{H}_2\text{O}$. All metals which at a red heat decompose water also decompose this acid, and cause an evolution of hydrogen, the reaction being expressed as follows: $\text{M} + \text{HCl} = \text{MCl} + \text{H}$. Hydrochloric acid gas is a common gaseous volcanic product. Free hydrochloric acid in a very dilute form is also a constituent of the gastric juice of man and animals, and plays an

essential part in the digestive process.

Commercial *muriatic acid*—to use the name employed by manufacturing chemists—is made by heating in iron cylinders common salt (chloride of sodium) and oil of vitriol (hydrated sulphuric acid), and condensing the evolved gas in water contained in a series of stoneware Wolfian Bottles (q.v.), the reaction being explained by the equation:



This commercial acid may contain various impurities—as, for example, iron (which gives it a bright deep yellow colour), the chlorides of sodium and arsenic—the latter being derived from the oil of vitriol—sulphuric and sulphurous acids, chlorine, &c., from which it can be purified to a great extent by dilution and redistillation. 'If pure,' says Miller, 'the acid should leave no residue when evaporated; on saturating it with ammonia it should give no precipitate of oxide of iron; sulphuretted hydrogen should produce no turbidity in it, which would be the case if arsenic, free chlorine, or sulphurous acid were present; and on dilution with three or four times its bulk of water no white cloud of sulphate of baryta should be produced by the addition of chloride of barium.' The presence of hydrochloric acid, or of the soluble chlorides in solution, may be detected by the addition of a few drops of a solution of nitrate of silver, which occasions the formation of a white curdy precipitate of chloride of silver, which is insoluble in nitric acid, but dissolves in a solution of ammonia.

Liquid hydrochloric acid (under the name of spirit of salt) was known to the alchemists. Hydrochloric acid gas was discovered by Priestley in 1772; and Davy in 1810 ascertained that it was composed of chlorine and hydrogen. In many of their properties the analogous acids, hydrobromic, hydrofluoric, and hydriodic acids, resemble hydrochloric acid.

Hydrocyanic Acid, HCN or HCy , known also as Prussic Acid, from its having been first obtained by Scheele in 1782 from the substance known as Prussian or Berlin Blue, is of almost equal interest to the chemist, the physician, and the toxicologist.

(1) *Chemistry.*—Pure anhydrous hydrocyanic acid is a colourless, highly volatile liquid, with a specific gravity of 0.697 at 64°F . It boils at 80° , and solidifies into a crystalline mass at 5°F . It possesses a very penetrating odour, resembling that of peach-blossoms or oil of bitter almonds. It burns with a whitish flame, reddens litmus paper slightly (its acid properties being feeble), and is very soluble in water and alcohol. Pure hydrocyanic acid may be kept unchanged if excluded from light, which occasions its decomposition, and the formation of a brown substance known as paracyanogen. Hydrocyanic acid is readily obtained by distillation from the kernels of bitter almonds and many kinds of stone-fruit, from the leaves and flowers of various plants, and from the juice of the tapioca plant (*Jatropha manihot*). Anhydrous hydrocyanic acid may be obtained by the action of concentrated hydrochloric acid on cyanide of mercury. The diluted hydrocyanic acid of the British and other pharmacopœias is, however, of more practical importance. It is made (*British Pharmacop.*) by distilling ferrocyanide of potassium with dilute sulphuric acid, and is standardised to a strength of 2 per cent. When kept for any length of time it is extremely apt to decompose.

The ordinary tests for hydrocyanic acid are (1) the peculiar odour; (2) the nitrate of silver test—there being formed a white precipitate of cyanide of silver, which is soluble in boiling nitric acid; (3) the formation of Prussian blue, by adding to the fluid under examination a solution of some proto- and per-salt of iron, by then saturating with caustic potash, and finally adding an excess of hydrochloric acid, when, if hydrocyanic acid is present, we have a characteristic blue precipitate; (4) the sulphur test, which is the best and most accurate that has yet been discovered. To the suspected liquid add ammonia and yellow sulphhydrate of ammonium; evaporate the liquid in a watch-glass to dryness, occasionally adding ammonia till the excess of sulphhydrate of ammonium is decomposed. Add water, and acidify with hydrochloric acid. If hydrocyanic acid be present

the sulphocyanate of ammonium which has been formed gives a blood-red solution on the addition of a ferric salt.

(2) *Medicinal Uses*.—Diluted hydrocyanic acid is used externally as an ingredient of lotions to diminish itching in skin diseases. In 2 to 8 minim doses it is given internally to diminish irritability of the stomach, to relieve gastro-intestinal pain, vomiting, and functional palpitation of the heart. Given by the mouth or by inhalation it is also useful in allaying cough in phthisis, whooping-cough, bronchitis, &c. All these applications depend upon its action in deadening sensory nerves.

(3) *As a Poison*.—Hydrocyanic acid is one of our most energetic poisons, and is frequently employed both for murder and suicide. When a small poisonous dose (about half a drachm of the 2 per cent. acid) has been taken the first symptoms are weight and pain in the head, with confusion of thought, giddiness, nausea (and sometimes vomiting), a quick pulse, and loss of muscular power. If death result this is preceded by convulsions and involuntary evacuations. When a large dose has been taken (as from half an ounce to an ounce of the 2 per cent. acid) the symptoms may commence in a few seconds, and it is seldom that their appearance is delayed beyond one or two minutes. 'When,' says Dr A. S. Taylor, 'the patient has been seen at this period he has been perfectly insensible, the eyes fixed and glistening, the pupils dilated and unaffected by light, the limbs flaccid, the skin cold and covered with a clammy perspiration; there is convulsive respiration at long intervals, and the patient appears dead in the intermediate time; the pulse is imperceptible, and the respiration is slow, deep, gasping, and sometimes heaving or sobbing.' The patient survives for a longer or shorter period, according to the dose. According to Dr Lonsdale, death has occurred as early as the second and as late as the forty-fifth minute; the poison acts as a paralytic to the whole nervous system. Death is due to paralysis of the heart in the more rapid cases, and to paralysis of the respiration in those which occur more slowly.

Where the fatal action is so rapid antidotes are of comparatively little value. Chlorine, ammonia, cold affusion, and artificial respiration are the most important agents in the treatment. The first two should be used with great caution, and only by the medical practitioner. Cold affusion on the head, neck, and down the spine is a valuable remedy. Artificial respiration (see RESPIRATION, ARTIFICIAL) should never be omitted.

Hydrogen (sym. H; atom. wt. 1; Gr. *hydōr*, 'water,' and *gennāō*, 'to produce') is an elementary gas and the lightest substance known. It is colourless, odourless, and non-poisonous, although as ordinarily prepared it frequently contains traces of disagreeably smelling or of poisonous impurities. The gas when subjected to enormous pressure at an extremely low temperature can be reduced to the liquid state. In combination with oxygen it forms one-ninth part by weight of water, and it is a most important constituent of the tissues of animals and plants. It enters into the composition of a large number of manufactured substances and products used in the arts, medicine, &c., as, for instance, starch, sugar, vinegar, gutta-percha, alcohol, ether, benzene, aniline, indigo, morphia, &c. It is not found largely in nature in the free or uncombined state, but it does occur in some gaseous emanations from the earth, as in the solfataras of Iceland and in the petroleum regions of Pennsylvania. Being the lightest gas known, its density is often adopted as the standard of comparison for the densities of other gases. The density of atmospheric air compared with that of hydrogen as unity is nearly 14.5. As hydrogen possesses the lowest atomic weight of all the elements, the atomic weight of hydrogen is almost universally adopted by chemists as unity, and those of the other elements referred to it; but at present there is a decided movement in favour of the adoption as standard of an atomic weight which can be determined with more rigid accuracy than that of hydrogen can.

Although hydrogen is usually classed amongst the non-metallic elements, it is in its chemical behaviour more closely related to the metals. It combines with oxygen, at a red heat forming water, this combination being accompanied by the giving out of a great deal of heat. A jet of hydrogen burns in air or oxygen with a non-luminous flame, which is, however, sufficiently hot to heat to

whiteness a fine platinum wire held in it. The behaviour of hydrogen towards chlorine is extremely interesting. The two gases can be mixed in equal volumes and preserved without combination taking place for an indefinite period if kept in the dark, but on exposure to diffused daylight combination begins, and its progress depends upon the brightness of the light and the duration of the exposure. Momentary exposure to direct sunlight causes combination to take place with explosive violence, and a similar effect is produced by raising any portion of the mixture to a red heat. Hydrogen as a rule combines with those things with which the metals in general combine, forming compounds which are analogous to those of the metals. Compounds containing hydrogen and one other element are common decomposition products of decaying vegetable and animal matters; as, for instance, marsh-gas, ammonia, and sulphuretted hydrogen, which contain hydrogen combined with carbon, nitrogen, and sulphur respectively.

Hydrogen gas, under the name of combustible air, was obtained in the 16th century by Paracelsus by treating certain metals with dilute acids, and was more or less known to Boyle and others; but Cavendish (q.v.) in his paper on 'Factitious Airs,' published in the *Transactions of the Royal Society* for 1766, was the first to describe accurately the properties of this gas, and the methods of obtaining it, hence he is usually mentioned as its discoverer.

The ordinary methods for preparing and purifying hydrogen will be found in any elementary treatise on chemistry.

Hydrometer, an instrument which indicates, by the depth to which it sinks in a liquid in which it floats, the specific density or specific gravity of that liquid. See SPECIFIC DENSITY.

Hydrogen Peroxide (sym. H_2O_2) is a compound of hydrogen and oxygen, containing a larger proportion of oxygen than water, the other compound of these elements. It was discovered in 1818 by Thénard, and was by him regarded as oxidised water as it very readily decomposes, when heated, into oxygen and water. The substance, when freed from water as completely as possible, is a thick transparent liquid, of specific gravity 1.45, without colour or smell, but possessing a bitter taste. It bleaches many vegetable colours, and when applied to the tongue or skin produces a white spot and gives rise to considerable pain. Its bleaching action and most of its chemical characters depend upon its powerfully oxidising properties. It is employed, in dilute solution, for the restoration of oil-paintings, its action upon these being an oxidising one.

Hydrophobia (Gr. *hydōr*, 'water,' and *phobos*, 'fear') is a symptom of a disease known as Rabies, which may occur in man and in various animals; but the word hydrophobia is also frequently used to denote the disease itself. It has long been known that rabies is communicated from one animal to another if the saliva of the one is introduced into the organism of the second; whether it be the case that the first has bit the second, or has only licked it on an open sore. The saliva of a rabid animal produces no injurious effect if brought in contact with the unbroken skin of an animal, or even with a mucous surface, provided it be not excoriated. The dog is the animal most frequently affected by rabies.

When a rabid dog bites another animal the latter shows no immediate symptoms of disease. The wound caused by the teeth of the dog behaves like an ordinary wound and becomes cicatrised in the same manner. After the lapse of a certain period, which may vary from nine or ten days to several months (cases are known where the time has been as long as twenty-six or twenty-eight months), but is generally from four to six weeks, the animal that was bitten exhibits special symptoms; rabies has declared itself. The time that has lapsed since the bite was received is called the period of incubation. When the affected animal is a man, the first symptom is usually a change of character; he becomes melancholy and distrustful. Next, generally at the beginning of the case, appears a symptom called *aërophobia*—the smallest breath of wind which touches the skin of the face causes its muscles to contract. Next comes hydrophobia—if the sufferer is offered anything to drink, his throat contracts, and he suffers

spasms of the pharynx. When this symptom appears the death of the sufferer is at hand, and is certain to occur in two or three days. During the interval between the appearance of the hydrophobic symptoms and death the patient has periods of calm and accessions of fury, and also exhibits paralytic symptoms which usually commence in the lower limbs.

Rabies is therefore communicated by biting from one animal to another; any scratch made by the teeth of the affected animal is harmless unless the saliva is conveyed to the wound. The animals liable to be affected by rabies are very numerous, and comprise almost all the mammalia—men, dogs, cats, horses, cattle, sheep, wolves, foxes, deer, &c.

The question of the etiology of rabies has remained very obscure until a very recent date; the most contradictory opinions were current when M. Pasteur in 1880 set himself to study this malady. His labours justify the following statements.

Rabies is a virulent disease, transmissible from one animal to another by the inoculation into the latter of those various secretions and tissues of the affected animal in which the virus dwells. This virus consists of a living organism which has not yet been made visible, by reason of the insufficiency of microscopic apparatus, but its existence can nevertheless not be denied. This statement, taken in connection with the results of M. Pasteur's labours in regard to the impossibility of Spontaneous Generation (q.v.), utterly contradicts the assertions of those who pretend to have observed rabies in animals which have never come into contact with rabid animals. Such assertions are always based on incomplete observations. If rabies could arise spontaneously in dogs, how can we explain the fact that vast regions like Australia may be wholly exempt from this scourge in spite of the great number of dogs there? The reason is that in these countries they most energetically prevent the introduction of any dog that can be suspected of rabies. If there were conditions under which rabies might spontaneously appear in dogs, then in territories so vast as the Australian colonies these conditions would certainly be realised from time to time. But there is no rabies in Australia.

M. Pasteur has studied the distribution of the virus in the individuals affected. He has observed that the virus was found in the nervous system and in the saliva, but not in the blood, the lymph, &c. Hence, if we inoculate another animal with the blood of a rabid beast, the first will remain wholly free of any rabid infection. Similarly, rabid virus introduced directly into the circulatory system of an animal will not produce rabies. But there is a sure means of communicating rabies from one animal to another—viz. by the introduction under the dura mater, on the surface of the brain, of a liquid which has first been sterilised and in which thereafter there has been soaked a portion of the central nervous system of the rabid animal. By this operation one is absolutely certain to communicate rabies unless the animal is refractory to rabies and cannot take the disease. In the course of his studies M. Pasteur observed that, in certain groups of animals which had been inoculated beneath the skin with large quantities of rabid virus, some not only did not take rabies, but became incapable of taking it—i.e. they might with impunity be inoculated on the surface of the brain with rabid virus. This observation was the origin of the discovery of preventive inoculation—of inoculation which renders an animal refractory to rabies.

The principle of such inoculation is as follows: The spinal cord of a rabbit which has died of rabies, when extracted from the body of the creature, and preserved in dry air at a constant temperature of 23° to 24° C. (74° to 76° F.), loses by slow degrees its virulence. With a spinal cord which has been so preserved for fourteen days it is impossible to communicate rabies to a rabbit or a dog. But this spinal cord has nevertheless still a certain power to confer immunity from the disease—the inoculation of an animal with a sufficient quantity of it will render it refractory to rabies. At the same time M. Pasteur observed that the freshest spinal marrow, that is to say, the most virulent, are those best fitted to confer immunity from infection. To render an animal refractory to infection the treatment commences by inoculating it with spinal cord fourteen days old, then with that of thirteen days, and so on till spinal matter three days old is reached, two days, one day, and even such as is not yet one day old. The last may be introduced into the subject of experiment without danger, because it is already

refractory.

What gives this discovery an enormous value is that these preventive inoculations made on an animal early enough and swiftly enough after it has been bitten prevent rabies from declaring itself. This is explicable on the following grounds: The virus is deposited by the dog's bite in a superficial wound; there it meets with little nerve-filaments in which it is further cultivated, and by means of which it ascends, somewhat slowly, to the nervous centres. These nerve-centres are the quicker affected the nearer to them the bite has been inflicted: hence bites on the head produce rabies after a shorter period of incubation than bites on the extremities of the body. If there is time to render the organism refractory by means of the preventive inoculations before the nerve-centres are affected the victim is saved; the nerve-centres once affected and destroyed, it is evident that no power of man can bring about a cure.

What ought to be done when any one is bitten by a mad dog is this. The wound made by the dog's teeth should be cauterised as soon as possible, and deeply too, so that if possible the virus may be destroyed before it has begun to cultivate itself in the nervous system. Then, if it is certain that the animal which inflicted the bite is mad, or if there is good reason so to believe, the victim should be sent as speedily as practicable to the nearest 'Anti-rabic Institute.' It is obvious that his safety depends on the quickness with which this is done. It is also obvious that bites on the head are more serious than bites on the limbs, inasmuch as there is a shorter distance to be traversed ere the nerve-centres are reached.

How can one make sure that the biting dog is mad? If possible the dog should be kept under observation without being killed; for it is much easier to recognise rabies in a living animal than by the earliest post-mortem examination. The animal will change its character, will often cease to eat, will bite everything within its reach, and will sometimes show signs of paralysis, its hind-quarters and its lower jaw being first attacked. In such cases the animal will inevitably die in from three to four days, or at most in eight days. A post-mortem examination will show the stomach empty of food, and containing on the contrary foreign substances such as bits of wood, stones, straw, &c. The most certain way of discovering if a dog was really mad is to introduce by way of inoculation a portion of its medulla under the dura mater of a rabbit. The rabbit will inevitably become rabid if the dog was rabid, but this will not take place till after fifteen or eighteen days; so that it would be imprudent for a person who had been bitten to await the result of the experiment before beginning to undergo preventive inoculation.

Statistics of the proportion of deaths by hydrophobia had never been properly kept up to the time of M. Pasteur's work in this department. Few doctors actually knew this terrible malady. It is generally said that of a hundred persons bitten by mad dogs some nineteen or twenty die of hydrophobia. This figure is probably too low. The mortality amongst cases treated at the Pasteur Institute (established by him in Paris in 1886) has fallen to less than $\frac{1}{2}$ per cent.

[So far M. Pasteur has sketched his discoveries and practice in regard to rabies, but a brief unargumentative review of current adverse criticism is also requisite. (1) As a working hypothesis, Pasteur assumes the occurrence of a specific microbe of rabies, which (in spite of various sanguine investigations) has not yet been demonstrated. In default of this demonstration, it seems to many that both the practice and the theory of rabid inoculation lack security and conclusiveness. (2) Again, there are some who, while believing vaccination to be empirically justified, are dissatisfied with the warrant for the anti-rabic treatment. They urge the acknowledged divergence between the two methods, and criticise the principle on which Pasteur works. (3) As to the warrant furnished by Pasteur's results, it is argued that the statistics are unreliable—e.g. because many of the patients inoculated were probably never infected, because in genuine cases the prevention may have been due to preliminary cauterising and to factors apart from the anti-rabic inoculation, and for various other reasons which forcibly suggest that in drawing inferences from statistics the sources of error are indeed numerous. (4) Less useful criticism is that which emphasises what is often true of progressive medical investigation—namely,

that there have been failures in Pasteur's treatment, that certain tentative measures were confessedly futile, that there have been striking changes of method, and so on. (5) More serious is the allegation that some deaths have occurred as the result of the inoculations rather than of the infection from the rabid animal. Of such not altogether unprecedented casualties the possibility, but not the actual occurrence, was admitted by the English Investigation Committee (1887), while Dr Armand Ruffer, who speaks with much authority, denies (1889) with all deliberateness that there is any case on record in which it can be proved that death has followed as the result of Pasteur's treatment. (6) The anti-vivisectionists have urged against certain implications of Pasteur's procedure various considerations which merit careful discussion, though without special bearing on the present problem. (7) So, too, the thorough-going anti-vaccinationists are of course among the critics of Pasteur, but their arguments can best be dealt with in connection with vaccine inoculation, about which we know at least a little more than we do in regard to the anti-rabic preventive (see VACCINATION). (8) Though there is much to be said on both sides, those who are willing to leave the problem to the experts will believe meantime that Sir James Paget, T. Lauder Brunton, George Fleming, Sir Joseph Lister, Richard Quain, Sir Henry E. Roscoe, J. Burdon Sanderson, and Victor Horsley had good reasons for saying in the Report which they presented to parliament in 1887: 'It may, hence, be deemed certain that M. Pasteur has discovered a method of protection from rabies comparable with that which vaccination affords against infection from smallpox.'

Hydrostatics treats of the equilibrium of liquids, and of their pressures on the walls of vessels containing them. It is a purely dynamic science, and concerns itself virtually with only two of the many physical properties of liquids. These are density and mobility. In virtue of the latter property, a liquid has no tendency to conserve its shape, so that if a distorting force acts on it it yields without any tendency to recover. It has no Elasticity (q.v.) of form. Viscosity (q.v.) may retard the rate at which the distorting force takes effect; but a liquid will continue to change form so long as there is a force acting on it which is not balanced by a perfect reaction. Thus, in hydrostatic problems, nothing of the nature of a distorting force is taken into consideration. All pressures acting on portions of the liquid must therefore be perpendicular to the surfaces on which they act; and equilibrium requires equality of pressure in all directions at any point.

The fundamental property may be thus stated: When a pressure is exerted on any part of the boundary of a liquid at rest, that pressure is transmitted undiminished to all parts of the mass and in all directions. Most of the other propositions of hydrostatics are only different forms or direct consequences of this truth, which may be proved experimentally. Suppose a close box B to be filled with water, and to have inserted into the upper cover a tube *a*, with closely-fitting plug or piston, 1 square inch in area. If the

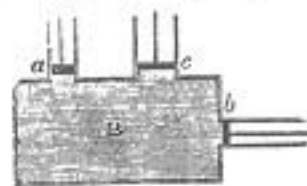


Fig. 1.

piston *a* is now pressed down upon the water with a force equal to a pound weight, the water, being unable to escape, will react upon the piston with the same force; but it obviously will not press more against *a* than against any other part of the box, therefore every square inch of the interior surface of the box is pressed outward with the force of a pound. If, then, there is another tube inserted in any part of the box with a plug of the same area, as at *b*, it will require a force of a pound to keep this plug in its place. (We leave out of account at present the pressure upon *b* arising from the weight of the water in the box above it—i.e. we neglect gravity and consider only the pressure propagated by the forcing down of the plug *a*.) However many plugs of the same size there may be, each will be pressed out with the same force of a pound; and if there be a large plug of four times the area, as at *c*, it will be pressed out with a force of four pounds. We have only, then, to enlarge the area of the piston *c* to

obtain any multiplication of the force exerted at *a*. If the area of *c* is 1000 square inches, that of *a* being 1 square inch, a pressure of one pound on *a* becomes a pressure of 1000 pounds on *c*; and if we make the pressure on *a* one ton, that on *c* will be 1000 tons. This seemingly wonderful multiplication of power has received the name of the *hydrostatic paradox*. It is, however, nothing more than what takes place in the lever, when one pound on the long arm is made to balance 100 pounds on the short arm.

If the pressure supposed to be exerted on the piston *a* arise from a pound of water poured into the tube above it, it will continue the same though the piston be removed. The pound of water in the tube is then pressing with its whole weight on every square inch of the inner surface of the box—downwards, sideways, and upwards. The apparatus called the *hydrostatic bellows* acts on this principle



Fig. 2.

(see fig. 2). It consists of two stout circular boards connected together by leather in the manner of a bellows, B. The tube A is connected with the interior; and a person standing on the upper board, and pouring water into the tube, may lift himself up. If the area of the upper board is 1000 times that of the tube, an ounce of water in the tube will support 1000 ounces at W. It is on the same principle that the Hydraulic Press (q.v.) depends.

(1) *Equilibrium of Liquids*.—After this explanation of the fundamental properties of liquids it may be enough to state the two conditions of fluid equilibrium which directly flow from it. (1) Every particle of the liquid must be solicited by equal and contrary pressures in every direction; otherwise there would be a tendency to motion, and therefore motion because of the liquid property of mobility. (2) The upper particles at the free liquid surface must form a surface perpendicular to the impressed force. The truth of this is experimentally demonstrated by the horizontality of the surface of a liquid at rest under gravity. It can be shown to be a consequence of the primary property of 'pressing equally in all directions,' for let *da* and *cb* be vertical lines, or lines in the direction of gravity; and *ab* a plane at right angles to that direction, or horizontal.



Fig. 3.

A particle of the liquid at *a* is pressed by the column of particles above it from *a* to *d*; and the like is the case at *b*. Now, since the liquid is at rest, these pressures must be equal; for if the pressure at *b*, for instance, were greater than at *a*, there would be a flow of the water from *a* towards *b*. It follows that the line *ad* is equal to *bc*, and hence that *dc* is parallel to *ab*, and therefore horizontal. The same might be proved of any two points in the surface; therefore the whole is in the same horizontal plane.

(2) *Pressure of Liquids on Surfaces*.—The general proposition on this point may be stated thus: The pressure of a liquid on any surface immersed in it is equal to the weight of a column of the liquid whose base is the surface pressed, and whose height is the perpendicular depth of the centre of gravity of the surface below the surface of the liquid.

The pressure thus exerted is independent of the shape or size of the vessel or cavity containing the liquid.

(3) *Buoyancy and Flotation*.—As a consequence of the proposition regarding the pressure of liquids on surfaces it can be shown that when a solid body is immersed in a liquid its loss of weight is equal to the weight of the displaced liquid—i.e. to the weight of an equal bulk of liquid. Thus, if a cubic foot of the liquid weighs the same as a cubic foot of the solid, the solid will appear to have lost all its weight, and will remain in the liquid wherever it is put; if a cubic foot of the liquid weighs less than a cubic foot of the solid, the solid will appear to lose part of its weight, and will sink; but if a cubic foot of the liquid weighs more

than a cubic foot of the solid, the immersed solid will not only lose all its weight, but will appear to be dominated by a *negative* weight, being urged upwards to the surface of the liquid by a force equal to the difference of the weights of the displaced liquid and the solid. In this last case the solid will rise until it swims or floats on the surface of the liquid, the amount of solid immersed in this

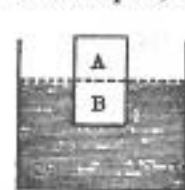


Fig. 4.

final state of equilibrium being determined by the obvious principle that a floating body must be buoyed up by a force equal to its own weight. Here again, then, the solid seems to lose all its weight, which loss must be simply the weight of the displaced water. Thus in fig. 4, where AB represents a floating solid, the water displaced by the immersed part B is equal in weight to the whole solid.

As the buoyancy of a body thus depends on the relation between its weight and the weight of an equal bulk of the liquid, the same body will be more or less buoyant, according to the density of the liquid in which it is immersed. A piece of wood that sinks a foot in water may sink barely an inch in mercury. Mercury buoys up even lead. Also a body which would sink of itself is buoyed up by attaching to it a lighter body; the bulk is thus increased without proportionally increasing the weight. This is the principle of life-preservers of all kinds. The heaviest substances may be made to float by shaping them so as to make them displace a volume of water greater than the bulk of their own solid substance immersed. A flat plate of iron sinks; the same plate, made concave like a cup or boat, floats. It may be noted that the buoyant property of liquids is independent of their depth or expanse, if there be only enough to surround the object. A few pounds of water might be made to bear up a body of a ton weight; a ship floats as high in a small dock as in the ocean.

(4) *Stability of Floating Bodies.*—Conceive *abd* (fig. 5) to be a portion of a liquid turned solid,

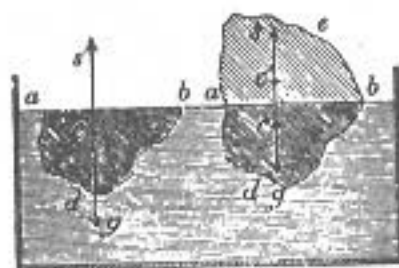


Fig. 5.

but unchanged in bulk; it will evidently remain at rest, as if it were still liquid. Its weight may be represented by the force *cg*, acting through its centre of gravity *c*; but that force is balanced by the upward pressure of the water on the different parts of the under surface; therefore, the resultant of all these elementary pressures must be a force, *cs*, exactly equal and opposite to *cg*, and acting through the same point *c*, otherwise the body would not be at rest. Now, whatever other body of the same size and shape we suppose substituted for the mass of solid water *abd*, the supporting pressure or buoyancy of the water around it must be the same; hence we conclude that when a body is immersed in a liquid the buoyant pressure is a force equal to the weight of the liquid displaced, and acting in the vertical line through the centre of gravity of the space from which the liquid is displaced. This point may be called the *centre of buoyancy*.

We may suppose that the space *abd* is occupied by the immersed part of a floating body *acbd* (fig. 5). The supporting force, *cs*, is still the same as in the former case, and acts through *c*, the centre of gravity of the displaced water; the weight of the body must also be the same; but its point of application is now *c'*, the centre of gravity of the whole body. When the body is floating at rest or in a state of equilibrium, this point must evidently be in the same vertical line with *c*; for if the two forces were in the position of *cs*, *c'g* (fig. 6), they would tend to make the body roll over. The line passing through the centre of gravity of a floating body and the centre of gravity of the displaced water is called the *axis of flotation*.



Fig. 6.

A floating body is said to be in *stable* equilibrium when, on suffering a slight displacement, it tends to regain its original position. The conditions of stability will be understood from the accompanying figures. Fig. 7 represents a body



Fig. 7.

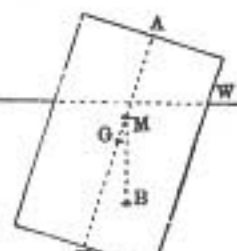
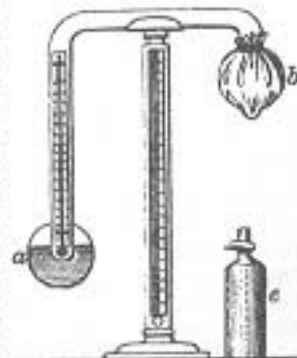


Fig. 8.

floating in equilibrium, *G* being its centre of gravity, *B* its centre of buoyancy, and *AGB* the axis of flotation, which is of course vertical. In fig. 8 the same body is represented as pushed or drawn slightly from the perpendicular. The shape of the immersed portion being now altered, the centre of buoyancy is no longer in the axis of figure, but to one side, as at *B*. Now, it is evident, that if the line of direction of the upward pressure—i.e. a vertical line through *B*—meets the axis above the centre of gravity, as at *M*, the tendency of the two forces is to bring the axis into its original position, and in that case the equilibrium of the body is *stable*. But if *BM* meet the axis below *G*, the tendency is to bring the axis further and further from the vertical, until the body get into some new position of equilibrium. There is still another case; the line of support or buoyancy may meet the axis in *G*, and then the two forces counteract one another, and the body remains in any position in which it is put; the body is then said to be in *neutral* equilibrium. In a floating cylinder of wood, for instance, *B* is always right under *G*, in whatever way the cylinder is turned. When the angles through which a floating body is made to roll are small the point *M* is nearly constant. It is called the *metacentre*; and its position may be calculated for a body of given weight and dimensions. In the construction and lading of ships it is an object to have the centre of gravity as low as possible, in order that it may be always below the metacentre. With this view, heavy materials, in the shape of ballast, are placed in the bottom, and the heaviest portions of the cargo are stowed low in the hold. See *SPECIFIC GRAVITY*.

Hydrosulphuric Acid. See SULPHUR.

Hygrometer (Gr. *hygros*, 'moist,' *metron*, 'measure'), an instrument for measuring the quantity of moisture in the atmosphere. The earlier forms of hygrometer depended upon the property possessed by some substances of readily absorbing moisture from the air, and being thereby changed in dimensions or in weight. Of this kind was the hair hygrometer of Saussure, in which a hair, which expands and contracts in length according as the air is more or less moist, was made to move an index; a similar instrument was the whalebone hygrometer of Deluc; but as other causes as well as moisture affect such instruments they afford no accurate indications. The most perfect hygrometer, theoretically, is that of J. F. Daniell (q.v.). It consists of two bulbs connected by a bent tube, as represented in the figure, and enclosing a thermometer, together with some ether and vapour of ether, the air having been expelled. The bulb *b* is covered with muslin, and *a* is either blackened or coated with metal. The observer's hand is placed for a short time on *b*, to drive the ether into *a*, leaving *b* and the tube filled with vapour of ether. A little ether is then dropped from a flask, of the form *e*, on the muslin-covered bulb; evaporation instantly takes place and produces a cooling of *b*, which condenses the vapour inside; a fresh evaporation from *a* fills the vacuum, which



is again condensed by dropping ether on *b*, and the process is repeated till the temperature of *a* is so reduced by successive evaporations

begins to be formed on the outside of the bulb. At the instant this occurs the height of the mercury in the two thermometers is accurately noted, the one giving the dew-point temperature, and the other the temperature of the air. The actual quantity of moisture contained in a cubic foot of air can now be readily found from the following empirical formula: weight of moisture in

grains = $\frac{5656 \cdot 2}{448 + t} \times p$; where *t* is the temperature of the air at the time of observation, and *p* (found from tables) the elasticity of vapour at the temperature of the dew-point. The evident defects of this instrument are, first, its rapidity of operation, so that no time is allowed for the glass, ether, and thermometer to come to the same temperature, and in consequence the dew-point is given higher than it actually is; secondly, its costliness, owing to the great consumption of ether; and, thirdly, its uselessness in tropical countries, owing to the difficulty of preserving the ether in a fluid state. Daniell's hygrometer was used at the Royal Observatory, Greenwich, from 1840—the commencement of meteorological observations—till 1847, when it was superseded by the more convenient instrument, the Wet and Dry Bulb Thermometers. This instrument consists of two ordinary thermometers: one has its bulb bare, and thus shows the temperature of the air; the other has its bulb covered with muslin, which is kept wet by a cotton wick dipping into water. The evaporation from the muslin, and consequent cooling of the bulb, being in proportion to the dryness of the air, the difference between the readings of the two thermometers is greatest when the air is driest, and zero when it is completely saturated. The readings of the thermometers being taken, the elastic force of vapour at the dew-point is calculated by the formula of Dr Apjohn:

$$(1) F = f - \frac{d \cdot h}{88 \cdot 30}; (2) F = f - \frac{d \cdot h}{96 \cdot 30};$$

the first formula to be used when the wet thermometer is above, and the second when it is below the freezing-point (32°). In these formulæ *F* is the elastic force of vapour at the dew-point, which has been determined for different temperatures by Regnault from carefully conducted experiments; *f*, the elastic force at the temperature of evaporation (or reading of wet bulb); *d*, the difference between the dry and wet bulbs; and *h*, the height of the barometer. From this the quantity of moisture in a cubic foot of air, &c. can be found as before. To dispense with these troublesome calculations the *Hygrometric Tables* of Mr Glaisher may be used, except in very dry states of the atmosphere, such as occasionally occur on Ben Nevis and very dry climates, when Dr Apjohn's formula must be used.

Hygroscope is a name sometimes given to an instrument for indicating the presence of moisture in the atmosphere, without measuring its amount. Hygroscopic substances are those which imbibe moisture and become coated with a moist film.

Hypochlorous Acid, HClO , is the acid contained in bleaching powder. It can only be obtained as a dilute solution, as in the concentrated state it is very liable to decomposition. It is a powerful bleaching agent, and forms a series of salts, *hypochlorites*, which also possess bleaching properties. The chief of these are the hypochlorites of lime and soda. The lime salt is the important constituent of bleaching powder, while the soda salt is prepared commercially by passing chlorine into a solution of soda. For further information, see *BLEACHING POWDER*.—*Hypo*, in composition (Gr. 'under'), is used much like *sub*, from Latin. Hypochlorous acid has less oxygen than chlorous acid; hyposulphuric has less oxygen than sulphuric, but more than sulphurous acid. Hypophosphates are salts formed by hypophosphoric acid and a base.

Hypodermic Injection. This method, first introduced by the late Dr Alexander Wood of Edinburgh, is an extremely valuable one in certain cases, though its applicability is limited. It consists in the injection of a solution of the substance to be given beneath the skin, by means of a fine hollow needle to which a small syringe is attached. The prick given by the needle is much less acutely felt by the patient if the needle be lubricated with carbolic oil or the like. Absorption from the subcu-

taneous tissue takes place speedily, and is not interfered with by vomiting, or other conditions of the stomach which may delay or prevent the entrance of the remedy into the system by that channel. The action of the drug is thus at once more rapid and more certain than when administered by the mouth; and a smaller dose is required. Only such substances as can be given in small bulk and in an unirritating condition are available. It is thus chiefly of use for the vegetable alkaloids, of which morphia is far the most often employed. It need hardly be said that it is to be used only by skilled hands. The same method is largely employed in experiments on the action of disease poisons in animals, and in Pasteur's treatment of hydrophobia.

Indigo (Gr. *Indikon*, 'Indian drug'), a most important vegetable dyestuff, yielding a beautiful blue and very durable dye, the basis also of the best black dye in woollen cloths. It has been used in India from a very early period, and was imported thence by the ancient Greeks and Romans, but was lost to Europe during great part of the middle ages—although the cultivation of the plant and preparation of the dye were described by Marco Polo in the 13th century—until re-introduced by the Dutch about the middle of the 16th century.



Indigo Plant (*Indigofera tinctoria*):
a, raceme of seed-pods. (From Bentley and Trimen.)

The plants that yield the best indigo belong to the genus *Indigofera*, of the natural order Leguminosæ, sub-order Papilionaceæ. *Indigofera tinctoria* is the species most generally cultivated in India. Central American and West Indian indigo is the produce of *I. anil* and *I. guatimala*.

Indigo is, however, obtained from plants of other genera, particularly from *Wrightia tinctoria* (natural order Apocynaceæ), East Indies; *Baptisia tinctoria* (natural order Leguminosæ), North America, which yields indigo of a pale colour and very inferior quality; *Tephrosia tinctoria* (natural order Leguminosæ), Malabar; *T. Apollinea*, Egypt and Nubia; *Marsdenia tinctoria* (natural order Asclepiadaceæ), in Sylhet; and *Polygonum tinctorium* and *P. Chinense* (natural order Polygonaceæ), China and Japan.—In times when East Indian indigo was not known, or was brought to Europe only in small quantity, the same dyestuff was obtained from Woad (q.v.).—A coarse kind of indigo, called Bastard Indigo, was also at one time made in North America from the young shoots of *Amorpha carulea* and *A. fruticosa* (natural order Leguminosæ).

In cultivating the indigo plant the seed is sown in drills about one foot apart at the beginning of the rainy season. Hoeing and weeding require to be assiduously attended to prevent the plants from being overpowered by weeds. The first crop is obtained in about three months after sowing. The stems are cut as the plants begin to flower, and quickly shoot up again, and in this way two and sometimes three crops are taken from the same plants in one season. Immediately the crop is cut it is tied in bundles and carried to the steeping vats to undergo the process of extracting the indigo; for an account of which see DYEING.

Green indigo, called *Lo-kaō* by the Chinese, is a substance resembling indigo, which is obtained from a tree called *Hom-bi*; it is highly valued by the Chinese artists as a pigment, and also gives a beautiful permanent green colour to cotton and silk cloths. It is, however, so costly that it never can, unless differently prepared, be used as a dyeing material.

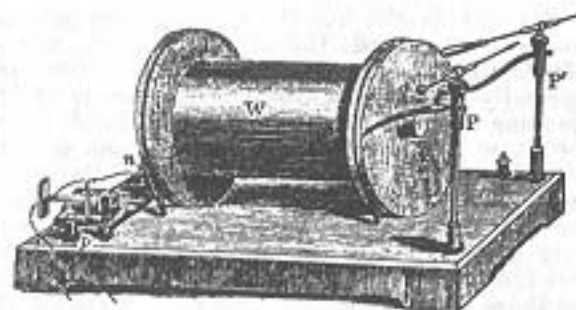
The indigo of commerce is by no means a homogeneous body. Its essential and most important constituent is *Indigotin* or *Indigo Blue* ($C_{16}H_{10}NO_2$), but it likewise contains *Indigo Brown*, *Indigo*

Red, and other ingredients. In 1878 Dr Baeyer of Munich, after many years of patient labour, announced the successful synthesis of an artificial indigo from phenylacetic acid, a coal-tar product. See DYEING.

Induction, in Electricity and Magnetism, is a term of various application. In every case, however, there is a certain idea present—the idea, namely, of an effect produced at an apparent distance from the producing cause, the effect being essentially a reproduction of the cause. More accurately stated, induction is the name of a method or mode by or in which a particular electric or magnetic condition is made to pass from one material system to another without the intervention of any obvious material connection. Thus, in static electricity a metallic body or other conductor brought into the neighbourhood of an electrified body becomes itself electrified by induction. Similarly, a piece of iron or other magnetisable metal, when brought near a magnet, or, more generally, when brought into a magnetic field, becomes itself magnetised by induction. Indeed, according to Faraday's view, induction is the essential feature in all electric and magnetic interaction. These two fundamental cases of induction will be found treated in full under ELECTRICITY and MAGNETISM.

There is, however, a third and very important group of electric and magnetic phenomena to which the name induction belongs. These were discovered by Faraday, and will be treated in a general way under MAGNETISM. The essential peculiarity of this class of induction phenomena is the production of electric currents in conductors or circuits in which there exists no source of electrical energy. These induced electric currents are in all cases the result of some magnetic change in the region occupied by the conductor. This magnetic change may be produced by the approach or withdrawal of a magnet; or it may be produced by the motion of the conductor in a constant magnetic field; or it may be due to variations of primary currents in neighbouring conductors, or even in the conductor itself. In this last case the variations of these primary currents cause corresponding variations in the magnetic fields existing with them, so that the induced current can always be explained in terms of a magnetic change. According to Ohm's Law (see ELECTRICITY), the strength of a current flowing through a given circuit depends on the electromotive force which excites the current, and on the resistance of the circuit through which the current is made to flow. In the case of induction of currents the electromotive force is directly due to, and is measured in terms of, the rate of change of the number of lines of magnetic force embraced by the circuit; and this rate of change depends on the geometrical form of the circuit and on its space relations to the magnetic field surrounding it. Thus the induced current depends on three things—viz. the form of the circuit, the varying space relations of the circuit and the magnetic field, and the ordinary ohmic resistance of the circuit.

One of the readiest ways of producing induced currents is to have two coils of wire, one placed inside the other, and to pass through the inner or *primary* coil a current of varying strength. At every variation of the primary current a current is induced in the outer or *secondary* circuit. The direction of the secondary current depends on the manner of change of the primary. If the primary current is decreasing in strength, the induced current in the secondary circuit flows in the same direction as the primary in its circuit; but if the primary current is increasing, the secondary current flows in the reverse direction. The best effects are produced at the 'making' and the 'breaking' of the primary circuit; for by these operations the primary current is made to have its greatest variations. This is the principle of action of the *Ruhmkorff Induction Coil*, one of the many forms of which is shown in the figure. The coils are wound, the primary inside the secondary, on the portion marked W. The battery wires, attached to the binding screws, p, n, are brought into connection with the terminals of the primary coil by means of the commutator, C. The terminals of the secondary coil are fixed to the brass heads of the glass pillars, P, P', which are furnished with pointed rods capable of universal motion. The true way of looking at the action of this



instrument is to regard the primary current as the source of a magnetic field within and around the coils. To intensify the magnetic field it is usual to introduce a soft iron core into the centre of the coils. In virtue of magnetic induction this iron core, under the influence of the magnetic force due to the primary current, becomes powerfully magnetised, and the magnetic field within the coil greatly increased. When the primary current is interrupted the iron core loses nearly all its magnetism, and accompanying this great decrease in the strength of the magnetic field an intense induced current flows in the secondary circuit. Now it is only when the magnetic field is varying that the induced electromotive force exists; and, since in a given secondary circuit the total current induced is proportional to the total change in the magnetic field, it follows that the more abrupt this change the more concentrated will be the flow of the secondary current.

In the induction coil matters are so arranged that the induced current is sufficiently concentrated to pass across a considerable air-space, which really forms part of the secondary circuit. By taking the terminals of the secondary circuit in our hands we may make ourselves part of this circuit, and experience the curious throbbing sensation of a galvanic shock. Or we may attach the terminals to the platinum wires of a Geissler tube, and produce the beautiful effects of electric discharge through gases in a state of great rarity. In most forms of induction coil the primary current is broken and made automatically, the varying magnetic strength of the iron core being used for this purpose. When the primary current passes, the iron core becomes a powerful magnet, and attracts a small iron disc set opposite one end. By means of a simple form of lever attachment this disc when so moved interrupts the primary circuit. The current then ceases to flow, the iron core loses most of its magnetism, and the small iron disc thus freed returns to its original position. With this return of the disc the primary circuit is again completed, the current flows as before, and the same order of effects is repeated, and so on indefinitely. In the secondary coil there is, of course, a possible induced current at make as well as at break. But, as in such instruments the corresponding magnetic change is not nearly so rapid at make as at break, the induced current is not so concentrated. Hence, practically, in working with an induction coil we have to do only with the induced current due to the interruption of the primary circuit.

The Telephone (q.v.) is an instrument whose action depends largely upon the laws of electromagnetic induction; and in the same category we may include the induction balance of Professor Hughes, which illustrates in a marvellous way the sensitiveness of a variable current flowing in a circuit to the presence of a small piece of metal or other conducting material.

Infanticide, or the murdering of infants, was common in ancient times, and still prevails in some barbarous communities. The practice existed in Greece and Rome, and even found defenders in Plato and Aristotle. The latter in his *Politics* said the law should forbid the nurturing of the maimed, and, where a check to population is required, abortion should be produced before the quickening of the infant. In Sparta, as in other Greek states, the law directed that when a child was born the father should carry it to an appointed place, there to be inspected by the elders of the community. If it was a promising child, they returned it to its parents to be educated; otherwise it was thrown into a cavern at the foot of Mount Taygetus. In ancient Rome the Twelve Tables directed malformed infants to be immediately destroyed, and by the *Patria Potestas* the father had an absolute power over his children extending

to life and death; but the rigour of the paternal law both as regards the killing and the sale of infants was softened by subsequent legislation, and especially by Numa. Among the Norse the child's life hung in the balance till the father handed it to the nurse to be reared. If it was weak or malformed, or if the father disapproved of its living, the child was killed by exposure to the weather and to wild beasts. According to Cæsar the Gauls were invested with the power of life and death over their children, and so late as the 13th century the Poles killed imperfect children. Amongst the Arabs it required an ordinance to prevent the crime of killing children lest the parent should be reduced to want, and this element of anxiety for the father's independence and comfort entered largely into the calculations of many states, barbarous and civilised, with regard to their posterity. The

Arabs also buried female infants alive.

In modern times infanticide prevails only amongst barbarous or semi-civilised nations, and even amongst these the increased intercourse with civilised states is gradually stamping out the practice. Until comparatively recent times child-murder prevailed throughout the whole of the South Sea Islands. In the Fijian island of Vanua Levu, or some parts of it, the infanticide reached, till the middle of the 19th century, a half and in others two-thirds of the child population. Amongst the Hindus the practice of destroying children, especially females, prevailed to a fearful extent, until it was checked under the Marquis of Wellesley's rule (1798-1805). The practice was forbidden by the Vedas; but, in consequence of the expense and the disgrace attached to girls remaining unmarried, the practice prevailed amongst the Rajputs—who destroyed all females except the first-born—and the native races. The methods of killing were poisoning by pills of tobacco, drowning in milk, smearing the mother's breasts with opium, and plastering the mouth with cowdung. Notwithstanding the Koran, the Mohammedans were inclined to the practice, but effected their object by means of abortion. Efforts began to be made towards the close of the 18th century, amongst others by Jonathan Duncan and Major Walker, for the suppression of the practice, and in 1853 these efforts were at last crowned with success at a durbar arranged for by Lord Lawrence. It was thought expedient to continue a system of surveillance by the police in some districts, and to institute a system of average numbers in families, which concentrated their vigilance upon those families which reached the lowest average. Amongst the Japanese the father had, but has not now, absolute power of life and death over his children. In China infanticide was, and in the remoter parts of that vast country still is, common. One of the causes here is the right possessed by Chinamen of periodically repudiating their wives. Sometimes the infants were stifled by the midwives at birth, and sometimes they were cast into a neighbouring stream, where in some cases they were humanely kept afloat by a gourd, so that they might be saved from destruction by any compassionate person who might feel disposed. In early missionary times it was a part of the duty of missionaries to pick up and rear, or entrust to others for the purpose of rearing, the waifs who had been abandoned through the avarice, poverty, or callousness of their parents.

In nearly all the cases mentioned infanticide was prompted by religious or economic reasons, or indulged in from caprice or indolence; and it was permitted in deference to the power with which in primitive communities as well as in advanced states like Greece and Rome the father was endowed. Modern civilisation deals very differently with the subject. In all European states, although they differ widely in their treatment of infanticide and cognate crimes, human life is from its first to its last hour held sacred, and whoever puts an end to it is a murderer. Almost the only motive which in such countries now leads to infanticide is that of shame—the parents incurring the risk of committing child-murder to escape social disgrace. The efforts therefore of legislators and criminal lawyers on the one hand have been directed to the repression of abortion, concealment of pregnancy, and murdering the new-born infant, and of philanthropists on the other to remove temptation to commit the graver crimes by providing Foundling Hospitals (q.v.), where the offspring of sin may find a refuge. See also ILLEGITIMACY.

In England and Scotland the inexcusable killing

of infants is theoretically murder, and the only excuse for killing the foetus is the safety of the mother; otherwise, Abortion (q.v.) is a criminal offence. The concealment of birth is also a criminal offence; see BIRTH (CONCEALMENT OF). The destruction of children may be effected negatively by not supplying food and clothing, as well as by the positive act of wounding or ill-treating; and if a parent or other person who is bound by law to supply food and clothing to the child refuses or neglects to do so, thereby causing its death, such refusal or neglect amounts either to murder or manslaughter, according to the circumstances. Moreover, the unlawful abandoning or exposure of any child under the age of two years, whereby the life and health of the child are endangered, is a misdemeanour punishable with three years' penal servitude. Where a person is charged with the murder of a very young child it is essential to prove that the child was in life. Under a statute of James I. there were presumptions against the mother, but in 1803 the trials for offences of this class were placed under ordinary rules of evidence. The presumption which now obtains that every new-born child found dead was born dead is believed by certain jurists to have encouraged infanticide. The test of a child being born alive is not that it breathed, or had an independent circulation after it was separated from the mother; it is enough that the child was fully born. Hence, if a man strike a woman with child, so as to cause the death of the child, he is neither guilty of murder nor of manslaughter of the child. In all cases of the murder of infants the question whether the child was fully born, and so the subject of murder, is generally one of medical jurisprudence. In England and Wales the annual number of verdicts of murder of infants one year old and under varied in 1879-88 from 65 to 103. The above offences in reference to infanticide are punished in a similar manner in Scotland, where, though the killing of a completely born infant is murder, a verdict of culpable homicide is frequently returned. Concealment of pregnancy is the usual charge under 49 Geo. III. chap. 17.

It has been stated that every day an inquest is held upon the bodies of children destroyed through the design, the neglect, the ignorance, or the mental infirmity of the mothers. Even when the act may fairly be regarded as a crime, its enormity is generally greatly lessened in the eye of the law by the consideration of the physical condition and moral disturbance of the parent.

An Act of 1872 obliges those who undertake for hire to nurse infants under the age of one year, for a longer period than twenty-four hours, to have their house registered, and to keep records of the children they take charge of. They must also give notice to the coroner or procurator-fiscal of such infants' deaths, and are under obligation to keep sanitary houses. By an important statute passed in 1889 any person over sixteen who wilfully ill-treats, neglects, abandons, or exposes a boy under fourteen or girl under sixteen years of age, or causes or procures this to be done, in a manner likely to cause the child unnecessary suffering or injury to its health, is guilty of a misdemeanour, and is liable to £100 of fine or imprisonment for two years, or to both. Lesser penalties are inflicted on summary conviction. The fine may be increased where the offender is proved to be interested in the death of the child.

Infernal Machines, contrivances made to resemble ordinary harmless objects, but charged with some dangerous explosive. An innocent-looking box or similar receptacle is partly filled with dynamite or other explosive, the rest of the space being occupied by some mechanical arrangement, mostly clockwork, which moves inaudibly, and is generally so contrived that, when it has run down at the end of a predetermined number of hours or days, it shall cause the explosive substance to explode. For a statement of the uses to which this class of infernal machines has been put by the anarchist parties, see DYNAMITE. Fire-ships (q.v.) were employed in former times; and modern nations apply a similar principle in their torpedo boats (see TORPEDOES). Bombs or hand-grenades, in so far as they have been employed for the felonious destruction of human life, must also be accounted infernal machines.

Influenza (Ital., 'influence'; called in French *la grippe*), one of the class of diseases to which the

term Zymotic (q.v.) is now applied, has been long recognised by medical writers. The popular application of the name to any severe cold in the head is not sanctioned by medical authority. Cullen called it *catarrhus e contagio*, but although, in most cases, it closely resembles ordinary catarrh, it presents certain points of difference from that disease. In addition to the ordinary symptoms of catarrh, there is a sudden, early, and very striking debility and depression of spirits. This early debility is one of the most marked and characteristic signs of influenza. The mucous membranes (especially those of the respiratory organs) are much affected. The tongue is white and creamy, the sense of taste is lost, there is no appetite, the pulse is soft and weak, the skin, although at first hot and dry, soon becomes moist, and the patient complains of pains and soreness in various parts of the body.

In simple, uncomplicated cases convalescence supervenes in the course of a week or sooner; but influenza is very frequently conjoined with bronchitis or pneumonia, in which case it is much more persistent and dangerous. There is, moreover, an extreme proneness to relapse on the slightest exposure, even after the patient feels perfectly recovered.

Influenza affords an excellent example of an epidemic disease, a whole community being often attacked in the course of a few hours. From this it may be inferred that the occurrence of this disease is connected with some particular condition of the atmosphere, but what that condition is is not known. Not unfrequently influenza follows close upon a sudden thaw; sometimes it is preceded by thick, ill-smelling fogs; but hot and cold, wet and dry weather have all been attended by severe outbreaks of the disease. Like cholera, influenza generally, but by no means constantly, follows a westerly direction, or one from the south-east towards the north-west, and its course seems to be altogether independent of the surface currents of air, as it often travels against the prevailing wind.

The epidemic which prevailed during the winter of 1889-90 in most parts of the civilised world, the first of importance in Britain for nearly forty years, presented some points of difference from most of the previously recorded outbreaks. In particular, there was in many places a much larger proportion of cases without any catarrhal symptoms whatever than appears to have been observed before. Such cases present a close resemblance to Dengue (q.v.), and many observers have come to the conclusion that there is a much closer relation between the two diseases than has been hitherto supposed; while some believe that the epidemic in question was itself dengue modified by climate, and not influenza at all.

The most important point in the treatment of influenza is *not* to bleed the patient, or in any way to depress his vital powers. He should be kept in bed; his bowels should be gently opened, his skin slightly acted upon, if dry; and, if the cough be troublesome, a mustard-poultice should be applied to the chest, and an expectorant mixture prescribed. Antipyrin and antifebrin were during the epidemic of 1889-90 found very valuable in combating the feverishness and pain of the early stage. In persons of weak or broken-down constitutions, ammonia, beef-tea, and wine and water must be given from the outset. The debility that often remains for a considerable period after the establishment of convalescence is best met by the preparations of iron, quinine, and strychnia.

Few diseases increase the death-rate to such an extent as influenza; more, however, in consequence of the great number of persons who are attacked in a severe epidemic, than in consequence of its danger in individual cases.

Infusions are aqueous solutions of vegetable substances obtained without the aid of boiling. In this respect only do they differ from decoctions, in the manufacture of which boiling is resorted to. Infusions are prepared by digesting the vegetable substance (root, bark, &c.) in hot or cold water in a covered earthenware vessel. Cold water is preferable when the active principle is very volatile, or when it is desired to avoid the solution of some ingredient in the vegetable which is soluble in hot, but not in cold water. For example, in preparing the infusion of calumba cold water is preferable, because it takes up the bitter principle (which is the essential ingredient), and leaves the starch-matter undissolved. In most cases, however,

boiling water is employed. Infusions are preferred to decoctions when the active principle volatilises at a boiling heat, as in the case of essential oils; or when ebullition readily induces some chemical change, as in the case of senna.

Infusions may also be prepared by Percolation (q.v.), a process which is extensively employed in the preparation of tinctures. When thus prepared they are less liable to decay than when prepared on the old system.

The fresh infusion, while possessing a finer flavour, is in danger of being superseded in pharmaceutical practice by the concentrated infusion. On account of the trouble and expense involved in making small quantities of the fresh preparations, recourse is frequently had to the concentrated ones, which, when diluted with seven times their bulk of distilled water, more or less represent the fresh article. Where the active principle is a volatile one it is very difficult to retain the full aroma in the concentrated state, and to this question much pharmaceutical attention has been turned. The concentrated infusions contain from 20 to 25 per cent. of alcohol, which is essential for their preservation. The simple infusions may be preserved for a short time by the addition of a trace of chloroform.

Infusoria, a name given to several classes of active Protozoa, some of which appear in great numbers in stagnant infusions of animal or vegetable matter. The great majority are provided with vibratile locomotor processes of their living matter, usually in the form of cilia or flagella; and, though these may be retracted when the animal occasionally encysts itself, they are practically permanent, and express the predominantly active constitution of these cells. Most are microscopic, but many are readily seen when foul water is held in a glass vessel between the eye and the light. Yet there may be more Infusorians in a cup of stagnant water than there are people on the globe. Infusorians occur both in fresh and salt water, and a few are parasitic; they feed on vegetable or on animal matter, on bacteria or on one another, while some possessed of a green pigment, closely allied to, if not identical with chlorophyll, probably absorb carbonic dioxide after the manner of plants. Most Infusorians possess a 'mouth'—i.e. a special aperture through which the food-particles are wafted in by the cilia or flagella. As single cells, comparable to the units of ciliated epithelium in multicellular animals, to the active spores of plants, and to male cells or spermatozoa, they exhibit the usual protoplasmic structure and the central differentiation or nucleus. There is usually a definite rind, often with cuticular structures; and there are generally contractile vacuoles, probably excretory in function. Many Infusorians occur not as single individuals, but as members of a colony, the results of multiplication remaining clubbed together, and often forming masses easily visible to the unaided eye. They multiply with great rapidity by dividing into two, or by rapid successive division into a larger number (spore-formation); and thus a single Infusorian, with favourable temperature and nutrition, may in four days become the ancestor of a progeny of a million, in six days of a billion, in seven and a half days of a hundred billions—weighing one hundred kilograms! If the life of the species, however, is to be sustained, conjugation or incipiently sexual union of two Infusorians (not of the same family) must occur, for if the descendants of one individual be left by themselves the whole family falls victim to 'senile degeneration,' and the members dwindle away. In many cases among ciliated Infusorians the researches of Maupas and others have shown that the conjugation of two forms means an interchange of nuclear elements; in other cases the two individuals fuse into one. When the two conjugates are of unequal size, as in the common Vorticella or bell-animalcule, it seems justifiable to call the smaller male and the larger female.

The classes included under the title of Infusorians are as follows, beginning with those ciliated forms to which zoologists often restrict the term.

Ciliata.—Infusorians characterised by the predominance of alternately bent and straightened motile processes known as cilia. The usual nucleus is accompanied by a second neighbour nucleus (para- or micro-nucleus), the elements of which are interchanged in conjugation. They are classified according to the relative position and size of their cilia. The slipper-animalcule (Paramacium), and

Opalina parasitic in the intestine of the frog illustrate those which are more or less completely ciliated (Holotricha); the beautifully-coloured species of Stentor, the genus Balantidium, with one species parasitic in man, and the common Bursaria are among those with heterogeneous cilia dissimilar in size and form (Heterotricha); the stalked bell-animalcule Vorticella and its beautiful allies Epistylis and Carchesium, the jumping Halteria, with a girdle of springy, bristle-like processes, and Ophrydium, which multiplies into large hollow colonies, sometimes 5 inches across, have a special wreath of cilia round the mouth (Peritricha); and lastly, those with cilia restricted to the under surface are well illustrated by Euplotes, Oxytricha, and Stylonichia.

Flagellata.—Infusorians with a vibratile or undulatory flagellum, or with more than one, used for locomotor or food-catching purposes, including a vast number of forms, some of which are often called Monads, while others—e.g. Volvox—approach if they do not unite with the Algae. One of the very commonest flagellate genera is Euglena. To the flagellates proper there have to be added the Choanoflagellata, with a single flagellum surrounded by a beautiful wine-glass-like collar—e.g. Salpingoeca, and the interesting Proterospongia—a colony with slight division of labour among its members and like a little fragment of sponge flesh; also the Dinoflagellata, with two flagella, one parallel, the other transverse to the long axis of the body—e.g. Peridinium, an extremely common marine form, affording food to some fishes; lastly, the Rhynchoflagellata, with a large locomotor flagellum, including two genera—the phosphorescent marine 'night-light' (Noctiluca), and Leptodiscus, a beautiful bell-like form, which seems within the compass of a single cell like a far-off prophecy of medusoid architecture.

Suctorio or Acinetaria.—Infusorians with cilia only in their free-living youth, usually fixed as adults, and always with prehensile or suctorial processes like tentacles, by means of which they prey upon other Protozoa. Acineta and Podophrya are suctorial; the common Acineta is only prehensile.

In beauty of form and movement, in the liveliness of their behaviour, and in the intricate phases of their life-history, Infusorians afford almost inexhaustible material for investigation, which many workers have shown to be at once captivating in itself and full of biological suggestiveness. In the general economy of nature Infusorians are especially important as a food-supply to small animals, and in so far as they unite with Bacteria in working decaying matter once more into the cycle of life, or in reducing it to simpler elements.

See BACTERIA, MONAD, PARAMECIUM, PROTOZOA, VORTICELLA.

Infusorial Earth, DIATOM EARTH, KIESEL-GUHR, a siliceous deposit formed chiefly of the frustules of Diatoms (q.v.). It is used as Tripoli Powder for polishing purposes, and as an absorbent of nitro-glycerine in making Dynamite (q.v.).

Inoculation ('enrafting'), the communication of disease to a healthy subject by the introduction of a specific germ or animal poison into his system by puncture or otherwise, originally used of the inoculation of smallpox (for preventive inoculation, see BACTERIA, GERM, ANTHRAX, HYDROPHOBIA). If the matter of a variolous (or smallpox) pustule, taken after the commencement of the eighth day, be inserted in or beneath the skin of a person who has not previously suffered from smallpox, the following phenomena are induced: (1) Local inflammation is set up; (2) on the seventh or eighth day there is fever similar to that of smallpox; and (3) after the lapse of three more days there is a more or less abundant eruption of pustules. This process is termed inoculation, and the disease thus produced is denominated inoculated smallpox. The disease produced in this artificial manner is much simpler and less dangerous than ordinary smallpox; and as it was an almost certain means of preventing a subsequent attack of the ordinary disease, inoculation was much practised till it was superseded in the beginning of this century by Jenner's introduction of vaccination. The importance of inoculation was recognised in the East at a very early period, the Chinese practising it from the 6th century, and the Brahmins from a very remote antiquity. In Persia, Armenia, and Georgia it was in use, and it is even said to have been employed in Scotland

and Wales. It was not, however, till Lady Mary Wortley Montagu wrote her celebrated letter from Adrianople in 1717 that the operation became generally known in England. In that letter she writes: 'The smallpox, so fatal and so general amongst us, is here entirely harmless, by the invention of enrafting, which is the term they give it. Every year thousands undergo the operation. There is no example of any one who has died of it, and you may believe that I am well satisfied of the safety of this experiment, since I intend to try it on my dear little son.' Four years afterwards she had her daughter publicly inoculated in England; the experiment was then performed successfully on six condemned criminals at Newgate, and on the strength of these successful cases two children of Caroline, Princess of Wales, were inoculated, which gave a sanction to the practice.

Inoculation was not, however, thoroughly established for more than a quarter of a century after its introduction. It met with virulent opposition both from the medical profession and the clergy. A sermon is extant which was preached in 1722, by the Rev. Edward Massey, in which it is asserted that 'Job's distemper was confluent smallpox, and that he had been inoculated by the devil.' The great drawback to inoculation turned out, however, to be this: while it was invaluable to him who underwent the operation, and completely guarded him from the natural disease in its severe form, its effect upon the community at large was extremely pernicious in keeping alive the natural disease, and increasing its spread amongst those who were not protected by inoculation. While one in five or six of those who took the natural disease died, the average number of deaths at the Inoculation Hospital was only 3 in 1000; and yet, according to the authority of Heberden, in every thousand deaths within the bills of mortality in the first thirty years of the 18th century (before inoculation was at all general) only seventy-four were due to smallpox. The deaths from this disease amounted to 95 in 1000 during the last thirty years of the century; so that, notwithstanding the preservative effects of inoculation on almost all who were operated on, the total number of deaths from this disease increased in one hundred years in the ratio of about 5 to 4. At the beginning of the 18th century about one-fourteenth of the population died of smallpox; whereas at the latter end of the same century the number (notwithstanding, or perhaps rather in consequence of, inoculation) had increased to one-tenth; and this immense consumption of human lives was not the total evil, for many survivors were left with the partial or entire loss of sight and with constitutions destroyed. The benefits which were expected from inoculation were far from being realised, and smallpox would doubtless have gone on increasing in its destructive power if it had not been checked by Jenner's discovery of Vaccination (q.v.). Inoculation was forbidden by law in 1840.

Insectivorous Plants. There are several hundred species of Dicotyledons which in some way or other catch insects and use them for food, either digesting their bodies or simply absorbing the products of their decomposition. They are remarkable for the adaptations of structure and function by which the insects or other small animals are secured, and for their obvious approach to the animal mode of nutrition. For it is a familiar fact that all typical plants feed at what may be called a very low chemical level, obtaining the required carbon from the carbonic acid gas of the air, and the equally essential nitrogen from ammonia, nitrates, and the like in rain-water and soil; while animals, on the other hand, do not derive their carbon from simpler substances than starch, sugar, and fat, nor their nitrogen from a lower source than the albumens manufactured by other animals or by plants. The insectivorous forms, however, break down the distinction in so far as they feed like animals on substances at a high chemical level; and the unity becomes more striking as we recognise that many of the insectivorous plants exhibit marked sensitiveness, mobility, and digestive power.

Altogether there are nearly five hundred species of insectivorous plants, referable to about twelve genera, and to half a dozen Dicotyledonous orders. They are represented in every great geographical region, perhaps with the exception of the African

wastes and the Argentine pampas. For convenience of treatment we follow Kerner in recognising three sets: (1) those with pits or cavities, into which small animals enter, but from which they are unable to return—e.g. Bladderworts and Pitcher-plants; (2) those in which the insect-catching depends wholly on the viscidness of the leaves—e.g. *Drosophyllum*; (3) those which exhibit distinct movements which help to secure the insects—e.g. Sundew and Fly-trap.

1. *With Pit-like Traps*.—The Common Bladderwort (*Utricularia vulgaris*, ord. Lentibulariaceae or Utriculariaceae) is a

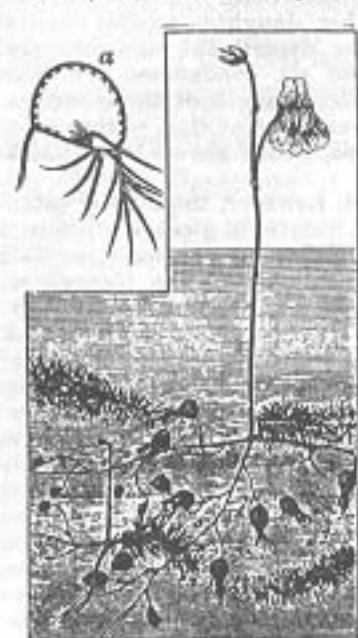


Fig. 1.—*Utricularia Graefiana*: a, section of bladder of *Utricularia neglecta*.

is a rootless floating water-plant, not uncommon on tarns and marshy lochs, but by no means conspicuous except in summer, when its handsome golden blossoms are raised on a flower-stalk about six inches above the water. Among the slender leaves borne on the straggling floating stem are numerous bladders, to which the plant owes its name. They are much modified dimpled leaf-organs, and form a simple but effective trap. As the figure shows, they are hollow chambers, entered by a door or valve which opens inwards only, and allows of no egress. Tiny crustaceans, known as water-fleas, whether chased by their enemies, attracted by a slight mucilage, or prompted by fatal curiosity, clamber on the antenna-like bristles which project from and perhaps protect the bladders. So far they are safe enough, but if they push their way through the narrow door, they find within the bladder a prison and a tomb. Escape is impossible, death ensues, and the products of decomposition are absorbed by sucking cells (fourfold hairs) on the walls of the bladder. Towards the end of summer, when the water no longer swarms with crustaceans, the *Utricularia* begins to die off, the life is concentrated in terminal buds, the bladders fill with water, and the plant sinks to the bottom. Thence it rises again in spring with a fresh equipment of buoyant bladders. There are numerous species of *Utricularia*, of which several are aquatic like the above; while others, especially in the tropics, are terrestrial. The booty of course changes with the situation, but the general habit seems to be the same throughout. We can only mention an allied genus, *Genlisea*, which has traps of a different pattern, approaching those of the pitcher-plants.

Among the *pitcher-plants*, the most familiar belong to the genus *Nepenthes* (ord. *Nepenthaceae*), which includes nearly forty species, widely distributed by swamps and jungle pools, 'from New Caledonia and New Guinea over tropical Australia to the Seychelles and Madagascar, over the Sunda Islands and Philippines to Ceylon, Bengal, and Cochin-China.' The young plant has a rosette of half-prostrate leaves, quite unlike those of the adult, with a terminal hooked crest overhanging a slightly hollowed broad lower portion. A stem shoots up, however, bearing other leaves, broad and spatulate in form, ending in a cylindrical tendril, which twists round adjacent branches and develops terminally into a large cavity or pitcher. The tendrils gradually lift the stem, and over the pool there eventually hang dozens of pitchers. These vary in size from a couple of inches to about a foot,

are usually brightly coloured with red, yellow, and purplish blotches, and bear two lateral flanges and a terminal lid, which opens when the pitcher attains its full size. Partly by the colour and partly by the honey glands of the lid and pitcher margin, insects are attracted; they sip the sweet secretion and venture farther down, only to land on an exceedingly smooth, waxed, slippery 'conducting surface,' whence they fall into the lower third or half of the pitcher, which contains water

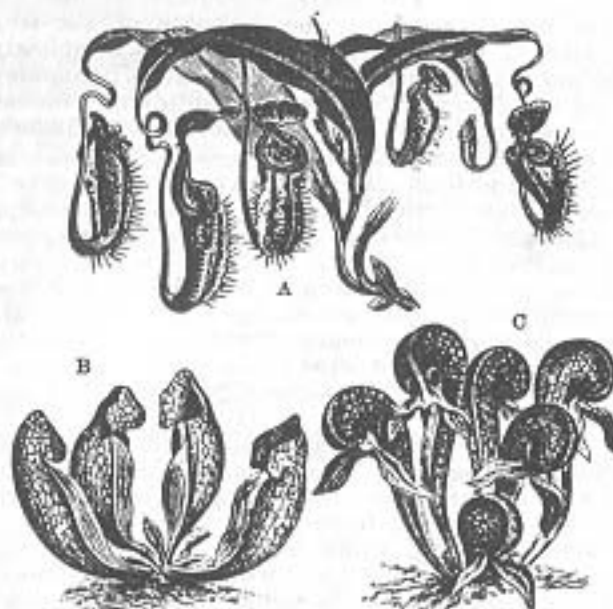


Fig. 2.—Pitcher-plants:

A, *Nepenthes Phyllanthiflora*; B, *Sarracenia purpurea*; C, *Darlingtonia californica*.

and digestive secretion. When an insect falls, the secretion is stimulated and becomes acid. As analysis has shown the presence not only of various

acids (malic, citronic, formic) but also of a peptic ferment, the fluid is exactly like that of an animal stomach, and the result is the same.

Another well-known pitcher-plant is *Sarracenia purpurea* (ord. *Sarracenaceae*), widely distributed in swampy regions of eastern North America from Hudson Bay to Florida. A rosette of half-prostrate leaves surrounds an erect flower-stalk. The pitchers are topped by a crest, which is decorated with reddish streaks, and disposed so that it catches rain-drops and lets them slide into the pitcher. Insects are attracted by the sweet secretion of glandular hairs on the lid or crest, wander farther down on a so-called 'conducting surface,' covered with downward-pointed hairs which forbid return, and eventually fall hopelessly into the water occupying the lower part of the pitcher. There they are decomposed and absorbed. Several inches of half-rotten insects are found at the base, rendering the water brown and putrid, and emitting a disagreeable smell. That digestion does not occur seems certain, and the fact is confirmed by Riley's observation that two insects—a fly (*Sarcophaga sarracenia*) and one of the *Lepidoptera* (*Xanthoptera semiothis*)—brave the horrors of the trap in safety, and utilise the dunghill of rotten insects as a suitable place wherein to deposit eggs. The grubs, which would perish if digestion occurred, thrive well and eventually bore their way through the sides of the leaf. Birds occasionally discover the store of insects and rifle the pitchers with their beaks. While all the species of *Sarracenia* probably agree in being non-digestive, they present considerable differences of structure, which we cannot here describe. Beside the above species—*S. purpurea*—may be ranked *Heliamphora nutans* (from Mount Roraima in British Guiana). In *S. variolaris* and in *Darlingtonia californica* (from the Sierra Nevada) the pitcher is capped by a helmet, so that no water can enter; the contained liquid must therefore be wholly a secretion, though still only putrefactive. Finally, *S. drummondii* and *S. undulata* are in external form almost nearer to *Nepenthes* and *Cephalotus* than to the other species of *Sarracenia*.

In the two species of *Sarracenia* last mentioned only some of the leaves are modified into pitchers, the others remaining green, lance-shaped, and unhollowed. So is it with *Cephalotus follicularis* (*Cephalotaceae*, near ord. *Ribesaceae*), which is restricted to a limited area near Albany in Western Australia. Here in the usual basal rosette only the lower leaves are pitchers, two inches or so in height, best adapted for catching ants and ground-loving insects. The outer surface bears ridges which help the insects up, and there are the usual attractions of bright colour and sweet secretion. Intoxicated, it may be, with the honey, or merely inquisitive and unwary, the visitors pass from



Fig. 3.—Pitcher of *Cephalotus follicularis*.

the sides or from the half-open lid to the slippery though corrugated margin, and thence fall into the liquid which fills half the pitcher. Endeavours to return are balked by a projecting shelf, by an area beset with stiff downward-pointed papillae, and by sharp spines round about the intumed margin of the collar. As the glandular secretion has an acid reaction and a solvent power, *Cephalotus* is also to be credited with true digestion.

In regard to the *morphology of the pitchers*, we shall simply cite the recent conclusions of Macfarlane: (1) The leaf in *Nepenthes*, *Heliamphora*, *Sarracenia*, and *Darlingtonia* is compound, and consists of from two to five pairs of leaflets; (2) there is a marked tendency to dorsal fusion of the leaflets from apex to base; (3) such fused leaflets are seen in the broad basal part of *Nepenthes* leaf, and in the flaps and lids of the various pitchers; (4) the pitcher itself is a deep dorsal involution of the midrib just above the termination of the fused upper pair of leaflets, except in *Cephalotus*, where, as Dickson clearly showed, it is an involution of the leaf-blade.

Very different from the pitcher-plants, and with appliances less involved for insect-catching, is the Toothwort (*Lathraea squamaria*, ord. *Scrophulariaceae*), a pale, chlorophyll-less parasite found in British woods, battenning on the roots of trees and shrubs. Excepting the flower-stalk, the stem is virtually underground; it bears suckorial roots and tooth-like leaves. The latter are hollow, and are entered through a narrow aperture by many kinds of small animals. These seem to be entangled in protoplasmic exudations within the leaf-cavity, find exit impossible, die, decompose, and are absorbed. Along with the toothwort ought also to be ranked *Bartsia alpina*, whose underground buds show a somewhat similar structure and carnivorous habit.

2. *Plants which catch Insects by Viscid Secretion without Pits or Movement*.—The best representative of this set is *Drosophyllum lusitanicum* (ord. *Droseraceae*), a native of Portugal and Morocco, growing with luxuriance in sandy or rocky places, to a height of about a span. The long linear leaves are richly beset with glands, many borne on long stalks, red in colour, and copious in an acid, viscid, dewdrop-like secretion, the others invisible to the naked eye, without stalks, colourless, and with an acid, dissolvent secretion, which is only exuded in response to the stimulus of some nitrogenous substance. Insects of various kinds alight on the long leaves, knock off the drops from the stalked glands, move anxiously about knocking off more and more until they are thoroughly besmeared, and their tracheae choked. Giving up the struggle, they sink on to the surface of the leaf, where the sessile glands begin the dissolvent and absorbent process. Kerner notes that the insect-catching is so effective that the peasants about Oporto use the *Drosophyllum* in their dwellings as a convenient substitute for fly-paper.

3. *Plants which exhibit Distinct Movements in their Insect-catching*.—The Common Butterwort (*Pinguicula vulgaris*), belonging to the same order as *Utricularia*, is a widely distributed representative of a genus including about forty species, all growing on more or less marshy ground (see fig. at BUTTERWORT). From a rosette of plump glistening

leaves there rises for several inches an upright stalk, bearing a beautiful two-lipped, spurred flower of a violet colour. The leaves have a distinct fungus-like odour, doubtless attractive, and are covered with glands, some stalked like miniature mushrooms, others almost sessile, both with a copious, viscid, acid secretion. This serves as 'insect-lime,' but, besides retaining the unwary midges, it finally digests them. Drops of rain may fall on the leaves, or pebbles may land there, but without noteworthy effect; a small insect, however, stimulates a copious flow of the fatal secretion. But there is also movement; for, when an insect is caught, the margins of the leaves slowly curl inwards for an hour or two, thus surrounding the booty, or shifting it nearer the centre, in any case exposing it to more glands. After digestion, the results and the surplus exudation are absorbed, leaving finally the undigested skin of the insect on the more or less dry leaf surface. More than 150 years ago Linnaeus noted how the Lapps used the butterwort for curdling milk, a property due to a rennet-like ferment which the plant has in addition to the digestive or peptic.

The antiseptic qualities of the ferments perhaps justify another old custom of applying the leaves to the sores of cattle.

Beside the butterwort on the marshy moor we are likely to find *Drosera rotundifolia* (ord. Droseraceæ) or some other species of sundew. Again, we have a rosette of prostrate leaves, from amid which rises a stalk with inconspicuous whitish flowers. Very striking, and constant in the forty or so species, are the red glandular 'hairs,' 'tentacles,' or processes which grow at different lengths from the upper surface and margins of the leaf. These are complex little structures with a head of glandular cells, supplied by numerous water-pipes (wood-cells or tracheides), and surrounded externally by a drop of viscid secretion. These tentacles are sensitive, mobile, secretory, digestive, and absorptive. To drops of rain they are indifferent, to irritant particles they may respond by increased secretion; but when a midge or a small particle of nitrogenous food is placed upon them, they become marvellously though by no means rapidly active. A living midge, which mistakes the secretion drops for nectar, lights on the leaf, and is forthwith entangled; as it struggles it becomes more hopelessly besmeared, and meanwhile the secretion becomes

truly digestive or peptic. More than that, however, the 'tentacles' curve down upon the victim, first one, and then, after an interval of ten minutes, another, till all the two hundred or perhaps half of them close upon the dying midge. The whole leaf may become concave if the booty is large, and then, after an hour or two of leisurely bending, the leaf looks like a closed fist. Many kinds of insects are thus caught, and even a dragon-fly may fall victim to the combined efforts of several adjacent leaves. The sensitiveness is finer than our most delicate nerves or balances, for a sundew hair will respond to a millionth of a grain of stimulating nitrogenous matter. The response is marked by the increased secretion and by the bending, while internal changes are traceable under the microscope passing from one cell to another down the tentacle. As one leaf may be seen with the remains of a dozen insects, and as there are half a dozen or so well-formed leaves, the carnivorous diet of the sundew is often considerable, and it has been demonstrated that the yield of seeds is better in those which are able to gratify their natural appetite.

Venus's Fly-trap (*Dionaea muscipula*), which Linnaeus called the miracle of nature, is in several ways a more elaborate insectivorous plant than any of the above, and is the climax of the order Droseraceæ. A native of the east of North America, with very local distribution, from Long Island to Florida, it grows on moorland, with a circle of more or less prostrate leaves round the base of a many-flowered stalk, which rises 4-6 inches from the ground. The leaves, about 4 inches in length, consist of a spatulate stalk, which is constricted to the midrib at its junction with the broad blade. The halves of the blade are movable on one another along the midrib, and close together as this volume would do if fitted with an automatic closing spring. Round each margin are twelve to twenty long teeth, which interlock in rat-trap fashion with those of the opposite side; the centre of the leaf bears numerous rosy digestive glands; and there are on each half of the blade three sensitive hairs, which rise obliquely, but bend flat on a basal joint when the leaf closes. The blade shuts up in 8 to 10 seconds when one of the sensitive hairs is stimulated, and if an insect is caught in the trap a profuse secretion is exuded from the glands. Digestion goes on for a week or a fortnight according to the size of the booty; finally the digested material and the secretion are absorbed, and the leaf then reopens. There is evidently division of labour to a greater extent than in the sundew, for the marginal teeth, the sensitive hairs, and digestive glands have separate functions. The delicacy of sensitiveness, the rapidity of movement, and the copiousness of the digestive secretion are noteworthy, while it is also significant that Burdon Sanderson has detected electric currents similar to those observed in the neuro-muscular activity of animals.

Superficially somewhat like the bladderwort, in its leaf-structure very like *Dionaea*, is an aquatic plant, *Aldrovanda vesiculosa* (ord. Droseraceæ), at home in south and central Europe, flourishing in ponds and pools where clear water is warmed by the summer sun. A thin rootless floating stem bears whorls of peculiarly modified leaves, dies away at one end as it grows on the other, forms in autumn a concentrated terminal tuft, which sinks to the mud at bottom and hibernates. Thence it rises again in spring lightened of its stores of starch and with buoyant air-spaces. The leaves consist of a spatulate stalk and a broad blade, which folds along the midrib like that of the fly-trap. The margin is firm, with small teeth, which meet those of the opposite side when the leaf is closed; externally a few long bristles project; the surface bears numerous longish hairs and also small stellate structures; there are large and small glands. When the water-flea, insect-larvæ, or even diatoms rest on the surface of the leaf, the half-blades close quickly as in the fly-trap, the victims are imprisoned, and, though they may remain alive for some days, there seems no doubt of their final absorption. Other species of *Aldrovanda* from Australia and Bengal seem to have the same habit.

Besides the true insect-catchers noted above, there are not a few plants—e.g. among the Saxifragæ, Sedums, and Primulæ, on the glandular surfaces of which insects are often entangled. These plants suggest how the insectivorous habit might begin, and there are two species in the sundew order, *Roridula dentata* and *Byblis gigantea*, in which the insect-catching seems to be more than incipient. Among the possibly insectivorous forms we must also include a Brazilian fern, *Elaphoglossum glutinosum*, and several liverworts—e.g. *Anomocladia mucosa* and *Physotium cochleariforme*. Zopf has recently described an interesting fungus (*Arthrobotrys oligospora*) which catches small threadworms in great numbers in its nooses, riddles their bodies with a growth of fine threads (hyphæ), and absorbs the tissues.

Utility.—The adaptations for catching and utilising insects are so numerous and effective, that we are apt to conclude too readily that the insectivorous habit is not only advantageous but necessary for the health of the plants. There are, however, several facts which suggest caution. Thus it has often been noticed that a leaf of sundew or fly-trap may suffer, and even die, from the effects of too big a meal, a serious enough objection to utility were the casualty not as rare in nature as it is common in experiment. More important is the difficulty raised by cultivators, who point to all sorts of insectivorous plants flourishing perfectly without any insect food. To this it can be retorted that the natural conditions of scanty nitrogenous supply are probably not observed in the greenhouse, but the facts force us to abandon belief in the necessity of the insectivorous habit. We can only maintain that it is normally advantageous, a conclusion confirmed in

some cases by the decrease in the quantity and quality of the seeds when no insects are available. From this, however, we need not conclude that the insectivorous function is the complete or even the original function of any of the curious leaf-structures above described.

Physiological Summary.—(1) It is a familiar fact that sundew and butterwort generally grow among bog-moss on the moors, hardly rooted in the soil, and therefore less adapted than ordinary plants to suck up the all-important nitrogenous compounds. The same relative scantiness in nitrogenous supplies is more or less marked in the habitats of other insectivorous plants, and doubtless renders them more dependent on their peculiar animal diet. All are said to be averse to the presence of much lime. (2) The diet is to some extent a matter of chance; both creeping and flying insects, small flies and even large moths, besides spiders, and centipedes are caught by the terrestrial and pendent traps. The aquatic bladderwort's most frequent victims are the small crustaceans known as Cyprids; while the subterranean *Lathræa*'s prisoners vary from the rank of mites down to infusorians. (3) The attractions of insectivorous plants are manifold; a mushroom-like odour in the butterwort lures insects which frequent fungi, and some of the others also appeal to the sense of smell; the 'dew-drops' of *Drosera*, the rosy patch on the fly-trap, the bright colours of many pitchers are obvious enough charms; while the frequent exudation of honey is the most direct lure of all. (4) In *Nepenthes* and *Cephalotus*, *Drosera* and *Drosophyllum*, *Dionaea* and *Pinguicula*, the bodies of the insects caught are digested, that is to say, chemically altered into soluble substances, which are absorbed by the cells of the leaf. The process agrees with animal digestion in the net result, and in the presence of a peptonising ferment and an acid. Too little is known about the ferment or ferments, and also about the various acids present; but there is no doubt in regard to their digestive activity. It is very important, however, to recognise, with Morren and others, that in plants digestion and the activity of ferments are by no means confined to the insectivorous forms. Thus the diastase which in germinating seeds, &c. turns starchy material into sugar is virtually the same as the ferment in the saliva, &c. of animals; similarly in both plants and animals there is an inverting ferment which turns cane-sugar into grape-sugar; there is also an emulsifying or saponifying ferment in plants, acting on fats and oils in a manner comparable to part of the rôle of the pancreatic juice. J. R. Green has described a rennet-forming ferment, comparable to that of the calf's stomach, not only in *Pinguicula*, but in the flowers of *Gallium verum*, in the stem of *Clematis vitalba*, in the petals of the artichoke, &c.; finally, a peptonising ferment has been detected not only in insectivorous plants, but in such diverse situations as the latex of *Carica papaya* and the seeds of *Vicia*. The protoplasmic

changes of plants are comparable to those of animals not only fundamentally, but also in many details, and the insectivorous plants are not unique, but simply conspicuous illustrations of vegetable digestion. (5) There is no doubt that both the products of digestion and the results of decomposition are absorbed by the insectivorous plants. Large stomata, protruding papillæ, suctorial 'hairs,' and other structures in the different plants are sometimes credited with this function, about which little definite information is yet forthcoming. An interesting, if hardly conclusive, corroboration of the absorbent activity is given by Clark, who fed *Drosera* with flies saturated in citrate of lithium, and some days later detected with the spectroscope the presence of the metal throughout the whole plant, in fact even in the flower. (6) The sensitiveness so marked in sundew and fly-trap is not of course unique, but is illustrated in the leaves, tendrils, stamens, stigmas, &c. of many plants, and may be compared—though we cannot go much further—with that of animals. Both *Drosera* and *Dionaea* respond to various kinds of stimuli, but usually and most readily to that of nitrogenous substances. Darwin gives numerous illustrations of the sundew's sensitiveness to extremely homœopathic doses ('000095 of a milligramme) of nitrate of ammonia and the like. In the fly-trap the sensitiveness, as we have seen, is definitely localised in the six jointed hairs. (7) The movements of sundew, fly-trap, and *Aldrovanda*,

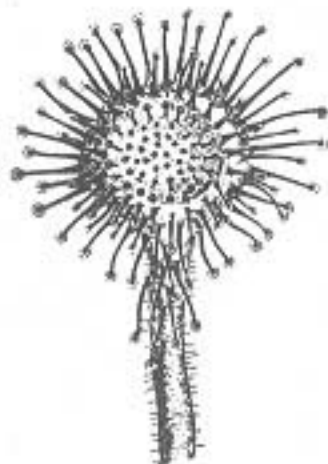


Fig. 4.—Leaf of *Drosera rotundifolia* seen from above.



Fig. 5.—*Dionaea muscipula*:
a, leaf.

like those in the leaves of the sensitive plant or the stem of the hop, the stamens of the barberry or the stigma of *Mimulus*, are associated with changes in the cells of the plant. It is easy enough to compare the movements with those of contracting muscles; but we are still far from being able to work out the comparison or determine the divergence. Four points may be noticed: (a) In the tentacles of *Drosera* the movement is associated with a visible change in the contents of the cells. Darwin described this, perhaps mistakenly, as 'aggregation of the protoplasm,' and compared it with analogous changes seen elsewhere. From what we know of movement in other plants, it is likely that the activity of the insect-catchers is connected with a change in the water tension or turgidity of the cells. (b) In the movement of *Dionaea* Darwin detected a measurable contraction or alteration of form; the same has been seen by Colin, Haeckel, and others in the mobile organs of other plants, and at once suggests the change of form in muscle-fibres. (c) Though there is no trace of anything like the nerves of animals, there is no doubt that a stimulus provoking motion passes from cell to cell and from part to part in both sundew and fly-trap. (d) Finally, Burdon Sanderson has described a resting and an action current of electricity in *Dionaea*, and concludes that 'the property by virtue of which the excitable structures of the leaf respond to stimulation is of the same nature as that possessed by the similarly endowed structures of animals.'

Although our knowledge of insectivorous plants dates from 1768, when Ellis sent to Linnaeus a description of the fly-trap and its habits, structural investigations prevailed until Darwin in 1860 began the thorough experimental study of insectivorous plants, comparing their sensitiveness, mobility, and digestive powers with those of animals. Since then the physiological interest of these plants has been kept steadily in view, our analysis of their vital processes becoming with each year more complete. At the same time, the morphology, especially of the pitcher-plants, has been studied with great success. The most difficult question concerning the origin and evolution of the insect-catching structures and functions is still a problem of the future.

Insect-powder is a greenish-yellow powder having a slightly pungent odour. When genuine it is prepared by powdering the closed flowers of various species of *Pyrethrum*, especially *P. carneum*, *P. roseum*, and *P. cinerariaefolium*. When dusted on fleas and other insects it soon stupefies and finally kills them, but whether this is due to subtle emanations from the oil or to the contact with the powder is undetermined. It is generally stated that the volatile oil does not possess this action, but the writer has noticed that when midges alight on a hand which has previously been rubbed with an alcoholic tincture of the powder they become stupefied, and in many instances rapidly die. The powder is innocuous to man, although it is stated to cause partial confusion of ideas in those who sleep in a room in which much of it has been used.

Iodine (sym. I, equiv. 127) is one of the four non-metallic elements. It was discovered in 1811, by Courtois, in the waste liquors produced in the manufacture of carbonate of soda from the ashes of seaweeds. A few years later Gay-Lussac discovered that it was a simple elementary body. While it is still obtained from the half-fused ash of dried seaweeds, which is known in Britain as Kelp (q.v.), it is much more largely prepared in South America from the iodate of sodium, which is found associated with nitrate of sodium in the native Chili saltpetre.

In small quantity, and usually in combination with sodium, magnesium, or calcium, iodine is very widely diffused over the earth's surface. It exists in sea-water, in marine animals and plants, and in certain mineral springs. It is also found in several minerals, as, for example, in certain Mexican silver ores, in Silesian zinc ores, in phosphorite from the Upper Palatinate, and in coal.

At ordinary temperatures it usually occurs in solid, dark-gray, glistening scales; it is, however, crystallisable, and sometimes appears as an octahedron with a rhombic base. It is soft, and admits readily of trituration, has the high specific gravity of 4.95, and evolves a peculiar and disagreeable odour, which indicates its great volatility. It fuses

at 225° (107° C.), and at about 350° (177° C.) it boils, and is converted into the purple vapour to which it owes its name (Gr. *iodēs*, 'violet-like'); it has an acrid taste, and communicates a brownish-yellow colour to the skin. It is very slightly soluble in water, but dissolves readily in watery solutions of iodide of potassium and of hydriodic acid, and in alcohol and ether. Iodine vapour is the heaviest of known vapours, its specific gravity compared with air as unity being 8.716. It combines directly with phosphorus, sulphur, and the metals. Its behaviour with hydrogen is analogous to that of chlorine and bromine (see HYDROCHLORIC ACID), but its affinities are weaker than those of the last-named elements. It likewise combines with numerous organic substances, and the compound which it forms with starch is of such an intense blue colour that a solution of starch forms the best test for the presence of free iodine. By means of this test one part of iodine may be detected when dissolved in one million parts of water.

With hydrogen iodine forms one compound, *Hydriodic acid* (HI), a colourless, pungent acid gas, which in most respects is analogous with hydrochloric acid. It may be obtained by gently heating a mixture of amorphous phosphorus, iodine, and water. The soluble iodides of the metals may be obtained by the direct combination of hydriodic acid with the metallic oxides, the resulting compounds being the metallic iodide and water. Some of these iodides are of extreme brilliancy—e.g. the iodide of mercury, scarlet; the iodide of lead, yellow; and others are of great value in medicine. Amongst the latter must be especially mentioned iodide of potassium, iodide of iron, and the iodides of mercury.

Iodide of potassium is one of the most important medicines in the pharmacopœia. It crystallises in colourless cubes, which are sometimes clear, but usually have an opaque whitish appearance, and are soluble in water and spirit. It is decomposed and the iodine set free by chlorine, bromine, fuming nitric acid, and Ozone (q.v.). Iodide of iron is formed by shaking iron wire or filings in a closed vessel with four times the weight of iodine suspended in water. There are two iodides of mercury—viz. the green sub-iodide (HgI) and the red iodide (HgI₂). There are several well-defined compounds of iodine and oxygen, but they are of no special interest.

The preparations of iodine are employed extensively in medicine and in Photography (q.v.). Iodine itself or its compounds may give rise to the symptoms known as *iodism*; most commonly running at the nose and eyes, with headache and sore throat; sometimes irritation of the intestinal canal, either alone or combined with the other symptoms. In the case of the iodine compounds these unpleasant results usually cease if the dose be increased.

Iodine and its compounds increase the activity of the absorbent system generally, and are useful in enlargement of the glands connected with that system (lymphatic glands, thyroid, spleen), and wherever absorption is deficient (hypertrophy of breasts, uterus, &c.; indolent inflammatory exudation in any organ). But they are perhaps of the greatest value in certain forms of chronic rheumatism, certain stages of syphilis, in scrofulous conditions generally, and in chronic poisoning by mercury and lead. In the last case they set free the metals from insoluble compounds in the tissues, and allow them to be eliminated from the body in solution in the urine.

Iodine is chiefly prescribed internally in combination, as iodide of potassium, iodide of iron, especially in strumous cases, and red iodide of mercury in syphilis. Free iodine is very apt to cause irritation of the intestinal canal, and can in general only be employed in small doses. But as an external application, in the form of ointment, tincture, or liniment, it is extensively used and is very valuable. It acts as a parasiticide in ringworm, removes muscular pains, and promotes the absorption of exudations and the subduing of chronic inflammations. In large doses iodine and most of the iodides act as irritant poisons; but very few fatal cases are on record. In the event of poisoning with the tincture of iodine the first point is to evacuate the stomach. See POISONS.

Iodoform (CHI₃) is a lemon-yellow crystalline substance, having a saffron-like odour and an unpleasant iodine-like taste. Its odour is most per-

sistent, and can hardly be removed. It is of interest as having a composition similar to that of Chloroform (q.v.), from which it only differs in having iodine in the place of chlorine. It may be prepared by the action of iodine on alcohol in the presence of carbonate of potash. It is almost insoluble in water, but dissolves in alcohol, ether, and chloroform. It is readily volatile when heated, and in the form of vapour has anæsthetic properties. It is employed externally as an application to painful ulcers, and it often gives relief in uterine cancer. In the form of iodoform gauze it is used in antiseptic surgery.

Ions, the components into which an electrolyte is broken up on electrolysis. The one, the Anion (the electro-negative component—e.g. chlorine), travels 'against' the current (in its conventional direction in the circuit), and is deposited on or chemically attacks the anode or positive electrode; the other, the Cation (the electro-positive component—e.g. copper), travels 'with' the current to the cathode—e.g. to the spoons in the plating bath. See ELECTRICITY.

Ipecacuanha, the name both of a very valuable medicine and of the plant producing it. The plant (*Cephaelis Ipecacuanha*) belongs to the natural order Cinchonaceæ, and is a native of the damp shady woods in Brazil and some other parts



Ipecacuanha (*Cephaelis Ipecacuanha*) in flower: a, the root.

of South America. More recently it has been cultivated in India and Ceylon, although there is a tendency under cultivation for the plant to run into varieties. It is somewhat shrubby, with a few oblongo-lanceolate leaves near the ends of the branches, long-stalked heads of small white flowers, and soft dark-purple berries. The part of ipecacuanha used in medicine is the root, which is simple or divided into a few branches, flexuous, about as thick as a goose-quill, and is composed of rings of various size, somewhat fleshy when fresh, and appearing as if closely strung on a central woody cord. Ipecacuanha root is prepared for the market by mere drying. It is collected at all seasons, although chiefly from January to March. The plant is never cultivated in Brazil. It has now become scarce in the neighbourhood of towns, but, owing to the readiness with which it is propagated from portions of the root, it is not likely to be exterminated.

It is in the bark of the root that the active principle, the *emetine*, almost entirely lies; the other ingredients, such as fatty matters, starch, lignine, &c., being almost inert. Emetine is represented by the formula $C_{20}H_{33}N_2O_6$. It is a white, inodorous, and bitter powder, moderately soluble in alcohol, and having all the characters of the vegetable alkaloids. It acts as a violent emetic in doses of $\frac{1}{16}$ th of a grain or less, and is a powerful poison. In good specimens of root it is present to the extent of nearly 1 per cent. In small and repeated doses—as, for instance, of a grain or less—ipecacuanha increases the activity of the secreting organs, especially of the bronchial mucous membrane, and of the skin. In larger doses of from 1 to 5 grains it excites nausea and depression; while in doses of from 15 to 30 grains it acts as an emetic, without producing such violent action or so much nausea and depression as tartar emetic. Ipecacuanha is useful as an emetic when it is necessary to unload the stomach in cases where there is great debility, or in childhood. As a nauseant, expectorant, and diaphoretic it is prescribed in affections of the respiratory organs, as

catarrh, hooping-cough, asthma, &c.; in affections of the alimentary canal, as indigestion and dysentery; and in disorders in which it is desired to increase the action of the skin, as in diabetes and in febrile affections.

Besides the Powder, the most useful preparations are the Wine of Ipecacuanha—of which the dose to an adult as a diaphoretic and expectorant ranges from 10 to 40 minims, and as an emetic from 2 to 4 drachms—and the Compound Ipecacuanha Powder, commonly known as *Dover's Powder* (q.v.). To produce the full effect as a sudorific a dose of 10 grains of *Dover's Powder* should be followed by copious draughts of white-wine whey, treacle-posses, or some other warm and harmless drink.

Iridescence, the sheen of mother-of-pearl and other objects possessing a finely-grooved surface. It is due to Interference (q.v.) between the waves of white light reflected from different levels in the grooving; some of the wave-lengths are more completely abolished by interference than others are; the result is that the residual vibration which reaches the eye contains a preponderant proportion of the rays which have been less affected by interference, and the reflected light accordingly presents colours which vary according to the angle of reflection.

Iron, sym. Fe (*ferrum*), atomic weight 56, sp. gr. 7.8 to 7.9; its density being increased by hammering, rolling, &c. Pure iron is a chemical curiosity obtainable in the laboratory by reducing pure oxide by charcoal or hydrogen at a very high temperature. A button of the metal thus obtained is white and of perfect lustre, very tough, and much softer than ordinary iron. Its melting-point is higher, so much so that if we attempt to fuse it when exposed to the air it burns before its melting-point is attained.

Ordinary commercial iron is protected from such combustion by the impurities it contains; these being more readily oxidised than the iron itself, while they lower its fusing-point. Carbon, silicon, sulphur, and phosphorus are the most notable of these impurities, but manganese, titanium, calcium, copper, arsenic, and other metals also occur in minute quantities in some samples. The proportions of all these are largest in crude or 'pig' iron, and in ordinary cast-iron. They are reduced to a minimum in wrought or malleable iron. The colour of this is gray or bluish-white; it is hard and lustrous, takes a high polish, is fibrous in texture, and when broken across exhibits a ragged fracture. It requires a very intense heat for its fusion, but before melting passes into a soft, pasty condition, in which state two or more pieces of iron may, by being hammered together, be united or welded so completely as to form, to all intents and purposes, a single piece. At a red heat it may be readily forged into any shape; but at ordinary temperatures it possesses very little malleability, as compared with gold and silver. In ductility it stands very high, being barely exceeded by gold, silver, and platinum; and its tenacity is very great; when combined with a little carbon it stands at the head of all the metals (see STEEL). Its susceptibility to magnetism is one of its remarkable characteristics (see MAGNETISM). At a high temperature it burns readily, as may be seen at the forge, or (more strikingly) when a glowing wire is introduced into a jar of oxygen. In dry air and at ordinary temperatures the lustrous surface of the metal remains unchanged; but in a moist atmosphere the surface rapidly becomes oxidised and covered with rust, which consists mainly of the hydrated peroxide of iron. At a bright red heat iron combines with the oxygen of steam and liberates hydrogen.

Native iron is a rare mineral, found in small grains in some basaltic rocks, and very rarely as thin veins. It occurs as one of the chief constituents of one class of meteoric stones. Its compounds are very widely distributed, more so than any other of the heavy metals. Nearly all of the sedimentary rocks are tinted by its oxides, and we cannot find a handful of soil on any part of the surface of the earth that is free from them.

(a) *Oxides of Iron*.—Iron forms four definite compounds with oxygen—viz. (1) the *protoxide* or *ferrous oxide*, FeO , which is the base of the green or ferrous salts of iron; (2) the *sesquioxide* or *peroxide* or *ferric oxide*, Fe_2O_3 , which is the base of the red or ferric salts; (3) the *black* or *magnetic*

oxide, Fe_3O_4 , which is regarded as a compound of the two preceding oxides; and (4) a questionable compound, *ferric acid*, FeO_3 . The *protoxide* cannot be obtained in an isolated state, but it forms the base of various ferrous salts, and combines with water to form a hydrate, $\text{FeO.H}_2\text{O}$, which, on the addition of an alkali, falls in white flakes provided the water in which they are suspended contains no free oxygen; otherwise the precipitate is gray.

The most important protosalts of iron, or ferrous salts, are the carbonate, the sulphate, the phosphate, and the silicate. Carbonate of iron or *ferrous carbonate*, FeO.CO_2 , exists naturally in various minerals, and may be obtained artificially by precipitating a soluble protosalt of iron with carbonate of potash or soda, when the carbonate falls in white flakes. On exposure to the air it absorbs oxygen and gives off carbonic acid, and is thus converted into the hydrated peroxide. Sulphate of iron or *ferrous sulphate*, $\text{FeO.SO}_3.7\text{H}_2\text{O}$ (or $\text{FeSO}_4.7\text{H}_2\text{O}$), is obtained by the solution of iron, or its sulphide, in dilute sulphuric acid; in the former case there is an evolution of hydrogen, and in the latter of sulphuretted hydrogen. On evaporation of the solution the salt is obtained in clear, bluish-green rhomboidal crystals containing seven atoms of water. This salt is commercially known as *copperas* or *green vitriol*. Phosphate of iron is obtained by precipitating a solution of a protosalt of iron with phosphate of soda, when a white precipitate of phosphate of iron is thrown down. All these salts, especially the carbonate and sulphate, are extensively used in medicine. Silicate and phosphate of iron occur naturally in many minerals.

The *peroxide* of iron, or *sesquioxide*, Fe_2O_3 , is obtained in an anhydrous form by igniting the protosulphate, and is known in the arts under the names *Colcothar*, *Crocus of Mars*, or *Rouge*, according to the degree of levigation to which it has been submitted. It is employed for polishing glass, jewellery, &c., and is also used as a pigment. It occurs both in the anhydrous and in the hydrated form in various minerals. The hydrated peroxide, $2\text{Fe}_2\text{O}_3.3\text{H}_2\text{O}$, is obtained by precipitating a solution of a persalt of iron with an excess of potash, ammonia, or alkaline carbonate. It falls as a yellowish-brown flocculent precipitate, which when dried forms a dense brown mass. Rust, as has been already mentioned, is a hydrated peroxide.

The most important of the persalts of iron, or ferric salts, are the neutral and the basic sulphate, whose formulæ are $\text{Fe}_2\text{O}_4.3\text{SO}_3$ and $\text{Fe}_2\text{O}_3.3\text{SO}_3.5\text{Fe}_2\text{O}_3$, respectively, the nitrate, $\text{Fe}_2\text{O}_3.3\text{NO}_3$, the phosphate, and the silicate. Of these the neutral sulphate, the phosphate, and the silicate occur in various minerals. The nitrate, which is obtained by the solution of iron in nitric acid, is a useful medicinal agent.

The *black* or *magnetic oxide* is formed when iron is heated in air or in oxygen, or in vapour of water.

(b) *Haloid salts of iron*—the chlorides, bromides, and iodides. There are two chlorides—viz. a protochloride, FeCl , and a perchloride or sesquichloride, Fe_2Cl_3 . The latter may be obtained by dissolving peroxide of iron in hydrochloric acid. The tincture of the sesquichloride of iron is much employed in medicine. The protiodide is an extremely valuable therapeutic agent.

(c) There are several *sulphides* or *sulphurets* of iron. The protosulphide, FeS , occurs in small quantity in meteoric iron. It may be obtained artificially by heating iron with sulphur. It is a blackish, brittle substance, retaining in some degree the magnetic properties of metallic iron. It is insoluble in water, but in moist air becomes oxidised into protosulphate of iron. With acids it develops sulphuretted hydrogen. The bisulphide of iron, FeS_2 , is the *iron pyrites* of mineralogists, and the *mundic* of commerce. Under the latter name it is used extensively in the preparation of oil of vitriol. The other sulphides are of less importance.

The *protosalts* and the *persalts*, or the *ferrous* and the *ferric salts*, give totally different reactions with the ordinary tests. The solutions of the former have a pale-green colour, while those of the latter are generally of a brownish-yellow colour. Sulphuretted hydrogen gives no precipitate with an acid solution of a ferrous salt, while it gives a milky precipitate of sulphur with a solution of a ferric salt. Potash, soda, and ammonia throw down a gray or green hydrated oxide from the

former, which changes to darker green and brown, and a brown hydrated peroxide from the latter. Ferrocyanide of potassium gives with ferrous salts a white precipitate, which soon becomes blue, while with ferric salts it at once produces a blue precipitate, even in a very dilute solution. Tincture of galls (tannic acid) produces no immediate change of colour with the ferrous, but a deep blackish-blue colour (ink) with the ferric salts. Sulphocyanide of potassium produces no change with the ferrous, but gives a deep blood-red tint with the ferric salts. Succinate and benzoate of ammonia produce no precipitate or change of colour with the former, while with the latter, if the solution is not too acid, they throw down pale reddish-brown precipitates.

MANUFACTURE OF IRON.—The increasing use of iron is a prominent characteristic of the present age, and every day sees some new application of it in the arts of life. Although the most useful of the metals, it was not the first known. The difficulty of reducing it from its ores would naturally make it a later acquisition than gold, silver, and copper (see BRONZE). The reduction of the ore known as the black oxide of iron, however, has been carried on in India from a very early time.

In Europe the rich specular and other ores of Spain and Elba were much used during the Roman period; in Greece, also, iron was known, though, as among the Romans, its use was subsequent to that of bronze. We are informed, too, by the Roman historians that this metal was employed by the ancient Britons for the manufacture of spears and lances. The Romans, during their occupation of Britain, manufactured iron to a considerable

extent, as is shown by the cinder-heaps in the Forest of Dean and other places. The rude processes then in use left so much iron in the cinders that those of Dean Forest furnished the chief supply of ore to twenty furnaces for between 200 and 300 years. In those early times the iron ores were reduced in a simple conical furnace, called an *air-bloomery*, erected on the top of a hill in order to obtain the greatest blast of wind. The furnaces were subsequently enlarged, and supplied with an artificial blast. Charcoal was the only fuel used in smelting till 1618, when Dud Dudley introduced coal for this purpose; but, the iron-masters being unanimously opposed to the change, Dudley's improvement died with himself. It was not reintroduced till Abraham Darby, in 1713, employed it in his furnace at Coalbrookdale. But, as this method was not properly understood, the production of English iron declined with the change of fuel, till, in 1740, it was only three-fourths of what it had formerly been. About ten years after this, however, the introduction of coke gave renewed vigour to the iron-trade, and then followed in rapid succession those great improvements in the manufacture which have given to the history of iron the interest of a romance. The introduction of Watt's steam-engine in 1770, the process of puddling and rolling invented by Henry Cort in 1784, and the employment of the hot-blast by Neilson of Glasgow in 1830 have each been of inestimable service. The greatest improvement introduced into the iron manufacture in recent times is the process of Sir Henry Bessemer for the production of mild steel, patented in 1856 (see BESSEMER). The 'Siemens-Martin' method of making steel has also of late come into extensive use.

Iron ores are abundantly distributed over the globe, the chief kinds being (1) magnetic iron ore; (2) red hematite, specular, or red iron ore; (3) brown hematite or brown iron ore; (4) carbonate of iron, including spathic ore, clay ironstone, and blackband ironstone.

The ore richest in the metal is the *magnetic* or *black oxide of iron*. When pure it contains nothing but oxygen and iron, its chemical formula being Fe_3O_4 , which gives 73 per cent. of iron by weight. It occurs in dark heavy masses or black crystals, and is found in the older primary rocks. Sweden is famous for this ore, and for the iron produced from it, which is esteemed the best in Europe. The celebrated mines of Dannemora, in that country, have been constantly worked since the 15th century. Russia, too, has great iron-works in the Ural Mountains, which are supplied with this ore. So also have Canada and several of the American states, as Virginia, Pennsylvania, New Jersey, &c. The rock formations in which magnetic iron ore occurs very rarely contain coal; hence it is locally smelted with wood-charcoal,

which contains no sulphur.

Red hematite contains a little more oxygen, its formula being Fe_2O_3 , that is to say, 70 per cent. of iron by weight if pure. The best ores actually contain from 60 to 67 per cent. There are several varieties of this ore. The first of these, *specular iron*, so called from its bright metallic lustre, occurs in large and beautiful crystalline masses in the island of Elba, where it has been worked for more than 2000 years, and is likewise found in many other parts of the world. It is of a steel-gray colour, assuming a red tint in thin fragments and when scratched. Another variety is *kidney ore*. Its characteristic form is in large kidney-shaped nodules, with a fine radiated structure. Red hematite is the most abundant variety. It occurs in massive deposits and in thin strata; some specimens are hard, others pulverulent and so soft that when rubbed it coats the fingers with an unctuous smear like plumbago, but of red colour. Its importance has much increased of late owing to its special fitness for making the pig-iron used in the ordinary Bessemer process. This valuable iron ore is found in great abundance at Whitehaven and Ulverston, in the north-west of England, where splendid masses of it occur, 15, 30, and even 60 feet in thickness. Vast deposits are found in the north of Spain near Bilbao, where it is now largely worked and exported to Great Britain, which in 1887 received from this source 3,597,202 tons, and 3,237,930 tons in 1888.

Brown hematite, or brown iron ore, is a hydrated peroxide of iron, and has the same composition as red hematite, except that it contains about 14 per cent. of water. It is generally found massive, more rarely crystalline, and a variety occurring in small rounded nodules is called *pea iron ore*. When mixed with earth or clay it forms the pigments yellow ochre and brown umber. Brown hematite is now an important ore in Great Britain. It occurs in different geological formations, chiefly in Devonshire, the Forest of Dean, South Wales, and in the county of Antrim in Ireland; also in an earthy form in Northamptonshire. It is the ore chiefly smelted in France and Germany.

Bog iron ore is an impure variety of brown hematite usually containing phosphorus. It occurs in curious pockets in peat.

Ilmenite is a dark-gray dense rock composed largely of peroxide of iron with varying quantities of titanate acid. It is found abundantly in Norway, and is now in practical use. The black sand found on the north-east shores of Canada, and at Taranaki, New Zealand, is similar, but the oxide of iron is magnetic.

Carbonate of iron, when found in a comparatively pure and crystallised state, is known as *spathic*, *spathose*, or *sparry iron ore*; but when impure and earthy, as *clay ironstone* and *blackband ironstone*. Spathic ore was little worked in England previous to 1851, soon after which it was discovered in Somersetshire. The Erzberg, near Eisenerz, in Styria, is the most famous locality for this ore, where it has been worked for ages. The spathic carbonates which are the richest in manganese have been much in demand to yield the spiegeleisen required in the Bessemer process. In its purest

form it contains 48 per cent. of iron; and in colour it varies from white to buff or dark brown, some specimens of it taking a beautiful polish, and looking like marble. The clay and blackband ironstones are essentially mixtures of carbonate of iron with clay, blackband having also a considerable proportion of coaly or bituminous matter. These dull earthy-looking ores occur abundantly in Great Britain. Until lately above one-third of all the ore mined in the country was obtained from the coal-measures, where fortunately both the fuel and the limestone, indispensable for the reduction of the iron, are also found. The ore occurs as balls or nodules, or in continuous beds.

The ancient iron-masters were unable to work any but the richest and purest ores, the magnetic oxides and hematites. The above table shows by the price and quantity of the North Riding ores that we are now able to work very poor and very impure material.

The most remarkable and useful property of carbon, that upon which its value as a fuel, &c. depends, is that when remaining at ordinary terrestrial temperature it is exceptionally inert, does not combine with the oxygen of the air or even with pure oxygen, nor with other elementary substances (fluorine perhaps excepted), but when

heated it acquires so greedy an affinity for oxygen that it not only burns in air—i.e. combines violently with its oxygen (see COMBUSTION), but will take oxygen away from most of its compounds, notably from the metallic oxides. This action of removing oxygen from oxides of metals and leaving the metal in the reguline or metallic state is called reduction, and the great reducing agent of the metallurgist is heated carbon. Hydrogen acts in a similar manner, and is also used as a reducing agent.

The ancient iron-masters obtained iron and steel by simply heating the purest obtainable oxides of iron with an easily-prepared and nearly pure form of carbon—viz. wood-charcoal. Their furnaces



Fig. 1.—Catalan or Corsican Furnace.

Space will not permit a detailed description of the various forms of ancient furnaces, but there is one that still survives in Europe which is typical and specially interesting. It is shown in fig. 1, and is known as the 'Catalan' or Corsican furnace. The blowing-apparatus is very curious and effective. *f* is the hearth or furnace with the tuyere or blowing-tube inserted in an opening of the wall. The bottom of the hearth is made of a sandstone that will bear great heat, and is lined with charcoal dust. A pile of rich ore, usually hematite, is placed on this and heaped up over the curved wall opposite the tuyere. The hearth is then filled up with charcoal and covered over with a mixture of charcoal dust and small ore, moistened and matted together. A gentle blast is applied at first, and when the flame bursts through the coating more of the same material is laid over to keep back the main charge until the mass is sufficiently heated for a fair start. Then the blast is turned on fully, and the ore that was piled on the curved wall is pushed down gradually as the lower portion is reduced, and this is continued until a mass of spongy iron, or 'bloom,' is formed. This is drawn out, hammered, and rolled with very primitive machinery. The ancient workers were not acquainted with the use of lime as an artificial flux, and hence the silica of the ore was got rid of by combining with some of the oxide of iron and thus forming a liquid-cinder (see SLAG).

The blowing-apparatus or 'trompe' shown in the drawing is used in mountainous countries where streams from high levels are available. The upper tank *a* is erected on a ledge of rock with one end overhanging, in this case supported by a tree-trunk. Connected with the large hole in the bottom is a wooden tube with oblique side openings, *b, b*. This tube terminates at the top of a lower tank *c*, which has an outflow opening at *d*, while its upper part communicates with the tuyere at *e*. The tank is otherwise closed and air-tight. At *a* in the upper tank is a plug to regulate the flow of water into the wooden tube. When water flows down this tube its velocity is of course accelerated as it descends. This acceleration divides the column

of water, and the spaces between become more or less vacuous. Consequently air rushes in at *b, b*, is dragged down by the descending water, and cannot return against the stream, but is forced by the rushing water through the narrow passage into the upper part of the lower tank, and there compressed in a degree that admits of regulation by raising or lowering the plug *a*. When the inflow of water is in excess of the outflow, the pressure increases, when the outflow is in excess it diminishes, when they are equal it remains steady, and thus the required variations of blast are regulated.

Modern blast-furnaces are hollow towers ranging from 30 or 40 to nearly 100 feet in height, and with internal capacities varying from 500 cubic feet to upwards of 25,000. The smallest furnaces are those used for smelting the richest and purest ores with charcoal, and, generally speaking, the poorer the ores the larger the furnaces, until we reach the maximum in the Cleveland district of the North Riding of Yorkshire, the metropolis of which is Middlesbrough.

Figs. 2 and 3 show a modern blast-furnace of ordinary dimensions (fig. 2) as seen externally (without its appliances for blast, &c.) and (fig. 3) in section. The external rings are of stout iron, bracing all the masonry together. The interior is lined with firebricks or other refractory material, the thickness of this lining or 'shirt' increasing downwards as the heat increases. Between the shirt and outer brick or stone-work an annular space is usually left which is filled with loose sand or fragments of slag to allow for shrinking or expansion of the interior. The larger furnaces have a double lining with such space surrounding each.

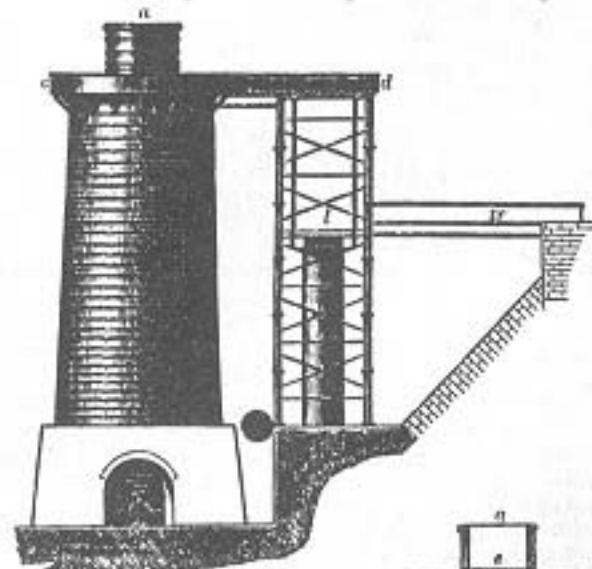


Fig. 2.

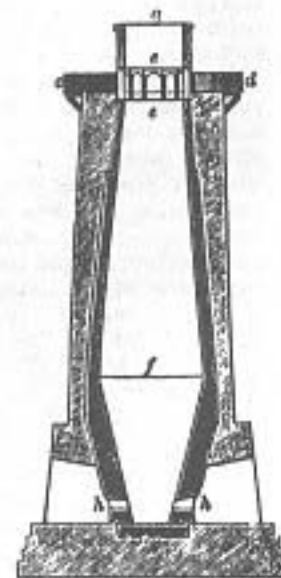


Fig. 3.

Blast Furnace.

The internal form is a matter of some practical importance. As shown in the section, the upper part or 'tunnel-head,' *a, e*, projecting above the surrounding gallery, is cylindrical. This part is not added to all furnaces. It merely acts as a chimney. Passing downwards we come to a continuation of this, *e, e*, which is called the 'throat,' the charge being pitched down this from the gallery through the arches or 'tunnels' that are shown in the section. Below this is a long truncated cone, *e, f*, called the 'stack,' extending to the widest part, which is called the 'belly'; this name, another form of the 'bosh' or 'boshes' (supposed to be a corruption of the German *bauch*), is applied to the lower inverted cone, which extends from *f* to *h, h*.

where the blast enters by the tuyères or tuyers (from the French *tuyau* or *tuyère*, which is freely translated in the Black Country to 'two irons,' as there are two iron tubes as shown in section, fig. 4, and externally, fig. 5).

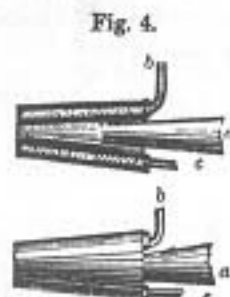


Fig. 4.

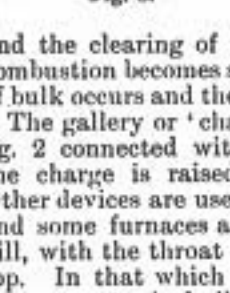


Fig. 5.

and the clearing of the walls; but below this the combustion becomes so active that rapid contraction of bulk occurs and the furnace is shaped accordingly.

The gallery or 'charging-plate,' *c, d*, is shown in fig. 2 connected with a hydraulic lift, by which the charge is raised to the level of the throat. Other devices are used, such as inclined planes, &c., and some furnaces are built at the side of a steep hill, with the throat nearly on the level of the hill-top. In that which is pictured the trolley-road or tramway, *tr*, is built up to about half height to meet the rising inner tube of the hydraulic lift at *l*. The materials charged into the furnace are ore, fuel, and flux, varying in proportion with the composition of the ore. The demand for flux is due

to the impurities of the ore. Lime is used for this purpose. It combines with the silica, and forms a readily fusible compound, a silicate of lime or lime-glass, which descends with the silicate of alumina, an analogous compound in the clay, and forms the 'slag,' or more properly 'cinder,' which floats on top of the fused iron in the crucible. The old iron-masters who used no such flux lost much of their iron by the combination of its oxide with the silica; hence the iron in the 'Dane cinders' of the Forest of Dean. In most of the modern furnaces the crude limestone is charged with the crude ore. Otherwise the ore is first roasted to expel the water of composition it contains (clay is a hydrated silicate of alumina) and the carbonic acid which is combined with the iron, and the limestone is similarly roasted in kilns to expel its carbonic acid. In the tall furnaces with hot-blast these operations are automatically performed in the upper part by the heat escaping from below. Formerly the coal was all coked before charging into the furnace; now raw coal or a mixture of coal and coke is used, and the coking, like the roasting, occurs in the upper part of the furnace. As the charge descends to the hotter and hotter parts of the furnace the oxide of iron, now dehydrated and dissociated from carbonic acid, becomes reduced to the condition of 'spongy iron.' The experiments of Sir J. Lowthian Bell show that such reduction occurs at a lower temperature than was formerly supposed. It is fairly started, if not

completed, before the limestone is fully calcined. The chief reducing agent is the heated carbonic oxide gas that rises from the incandescent mass below. This gas, a compound of one equivalent of carbon with one of oxygen, CO , combines greedily with oxygen when heated, and forms carbonic dioxide (carbonic acid), CO_2 . In this case it does so by taking away the oxygen from the oxide of iron. The hydrocarbons formed by the distillation of the coal probably co-operate. The spongy iron thus formed corresponds to the final product, the 'bloom' of the Catalan and other primitive furnaces. The iron itself is pure enough, but is entangled with the earthy impurities of the ore. The bulk of these impurities is finally removed by the flux, but before this occurs another and rather vexatious action occurs at the full and bright red-hot region below. This is described by Sir J. L. Bell as the 'zone of absorption,' for here the spongy iron absorbs impurities that have afterwards to be removed by the puddler. It takes up carbon, silicon, sulphur, and phosphorus from its surroundings, the sulphur and carbon from the coal, the silicon and phosphorus from the ore. These, though mischievous, assist the work of the blast-furnace; they lower very considerably the fusing-point of the iron, the pure spongy iron being practically unfusible in an ordinary furnace. The manner in which the spongy iron

appears to obtain its carbon is curious. Carbonic oxide when highly heated (2190°F.) is dissociated into carbon and carbonic acid. One half of a given quantity loses its oxygen and gives it over to the other half. Taking two equivalents of carbonic oxide, containing two of carbon and two of oxygen, the change may be represented thus:

$$\begin{array}{c} \text{O} \\ \text{C} \end{array} \rightarrow \text{CO}_2$$

$$\text{C} \rightarrow \text{C}$$

Sir J. Lowthian Bell, who has devoted an immense amount of costly labour to the investigation of the contents of various parts of the blast-furnace, maintains that this dissociation occurs at a much lower temperature in the blast-furnace than in Deville's apparatus, possibly owing to the help of the iron in combining with the flocculent carbon immediately it is thus separated.

After these changes are completed, fusion speedily occurs in the rapidly-contracting region of the furnace, and finally the whole contents of the furnace, excepting those which are converted into gases that escape from the top, are liquefied and fall into the crucible as two distinct fluids, the melted crude iron, and the cinder or slag. The latter floats above the metal and runs out over a dam by a specially-constructed orifice. While thus covering the iron it protects the metal from oxidation, and this continues until the metal accumulates sufficiently to reach the 'cinder notch' of the dam. When this occurs the furnace is tapped—i.e. a plug which stopped a channel-hole at the bottom of the crucible is removed, and the molten crude iron flows in a glowing stream down long channels in a bed of sand. Side-channels of moderate length branch out on each side of the main channels, as near to each other as possible, and these are filled with the iron. In the poetic language of the Black Country the main channel is called the 'sow,' and the smaller branching channels the 'pigs.' Hence the well-known name of 'pig-iron.'

The table below shows the composition of pig-iron; the first being the mean of twenty-nine brands of high-class pig, the second of a common Cleveland pig; the analyses made by the writer:

Combined Carbon	0.91	0.80
Graphitic Carbon	1.92	1.00
Silicon	1.31	2.23
Phosphorus	0.33	1.30
Sulphur	0.25	0.27
Manganese	1.28	0.71
Iron by difference	93.50	93.69
	100.00	100.00

Pig-irons are technically described as gray, mottled, and white, and commonly numbered accordingly, commencing with the gray as No. 1, down to No. 8, the extreme white. Gray pig-iron is granular and easily drilled or filed, owing to this structure; white pig is crystalline and very hard, harder than the hardest steel. This difference is mainly due to the different conditions of the carbon. In the gray it is nearly all uncombined or graphitic; in the white, nearly or quite all combined; the mottled is intermediate. It is easy to pick out with a penknife from a good sample of No. 1 pig brilliant scales of graphite, technically described as 'kish.' Good samples of pig-iron are used directly for making castings, or the pig-iron is refined (see below) for this purpose. Such 'cast-iron' is brittle in proportion to the impurities it contains. In its ordinary condition it is neither malleable nor ductile, though small castings of a superior quality of refined iron may be rendered tougher by careful annealing. These 'malleable castings' are now largely used.

One of the important improvements of modern ironmaking is the use of the hot-blast. Very great economy of fuel is thereby effected. A great variety of ovens for heating the blast have been patented. Their essential principle is passing the air through tubes or passages of iron or fireclay that are heated by a flame or hot air surrounding them. The heat is usually obtained by utilising the waste inflammable gases that formerly blazed away to waste from the top of the blast-furnace. For this purpose the tunnel-head (*a, c*, figs. 2 and 3) is cut down, or not built, and the charge is thrown upon a stopper, which is movable in such wise as to drop the charge with little or no escape of the gases

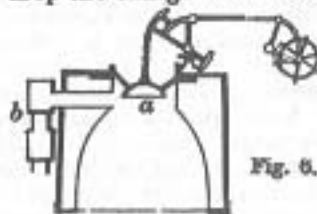


Fig. 6.

from the interior of the furnace. The most common of these devices is the 'cup and cone,' shown in fig. 6, where *a* is the cup that plugs the opening of the truncated cone

above. The charge is pitched into this inverted cone and rests there till the cup is

lowered, when it falls around the cup. In the figure the furnace is shown closed. The inflammable gases then descend by the pipe *b* to their destination.

In order to obtain ordinary malleable iron from pig-iron the bulk of the impurities are removed by 'puddling' and hammering or squeezing. The old iron-masters simply melted the crude iron in a refining furnace or 'finery,' and then subjected it to the action of a blast, which sufficiently oxidised the silicon and carbon. Where these are the only impurities that require removal this treatment is still used; but such severe oxidation fails to remove the sulphur and phosphorus. The refining furnace, which is still used to some extent for the conversion of gray into white cast-iron, or as preliminary to puddling, is shown in section in fig. 7. The pig-iron and coke or charcoal are charged into the space *D*, the blast is driven through the blast-pipes, *C, C*, to the tuyères, as shown. After starting well with fuel below, the coke continues to burn and the iron to melt, and both are continuously charged, the melted iron flowing down to the hearth below, where the blast strikes upon its surface and oxidises the carbon and silicon, at the same time circulating the fluid metal by its stirring action. If this is continued long enough, a bloom or ball of malleable iron is produced. With less blowing the silicon is for the most part burned out, and the graphitic carbon is caused to

combine by the high temperature attained, and thus 'white iron,' suitable for foundry purposes or for puddling, is produced. In this case the melted iron is run into a shallow hearth, and there allowed

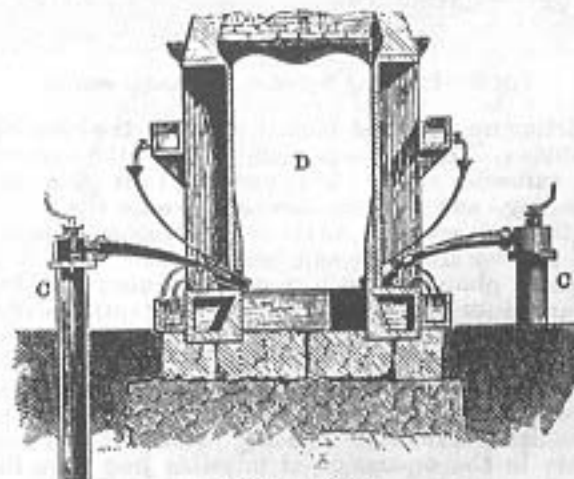


Fig. 7.—Finery.

to cool and throw up a film of silicate, which easily separates from the refined metal below. This is broken up into convenient pieces, and is commonly described as 'plate' iron.

The Bessemer process (see BESSEMER STEEL) is but a modification of this, the difference being that, instead of blowing on the surface, the Bessemer blast is introduced below, and therefore acts more thoroughly.

The puddling furnace, in which the puddling process is conducted, is shown in vertical section in fig. 8, where *f* is the fireplace, *br* the

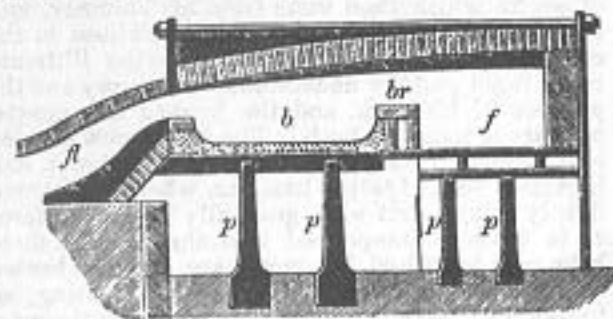


Fig. 8.—Puddling Furnace, vertical section.

bridge, *b* the bed, *f* the flue, and *p, p, p, p*, iron pillars supporting the furnace. It is constructed of firebricks, and the whole, excepting the flue, is encased in strong iron plates firmly strapped together by iron rods. When the fire is blazing the flame surmounts the bridge, strikes the arched roof, and 'reverberates' down upon the contents of the bed, and passes along the flue to a short chimney, which is surmounted by a damper-plate that may

be raised and lowered to regulate the draught. Fig. 9 is a horizontal section with the same lettering, excepting that *s* is added to show the working-door or stopper-hole through which the puddler works. When the roof, walls, and bed of the furnace are moderately heated the puddler 'fettles' his furnace by plastering the bed and sides with a 'fettling' composition, which consists essentially of ground oxide of iron made into a paste with water. Hematite is the best fettling; 'bulldog,' made by roasting refuse cinder, is cheaper, and largely used. Lumps of crude iron are now thrown in, the fire is made up, the doors closed, and damper

raised to 'rouse' the whole and melt the charge, which usually amounts to 4½ cwt. Two men work the furnace, the 'forehand' and his 'underhand.' During the melting the underhand turns over and distributes the lumps with a long iron rod. When the melting is completed a heavier iron bar, flattened and bent at the working end, is used. This is called the 'rabble,' and with it a vigorous stirring or 'rabbling' is kept up. The work is very exhausting, and the men work in turns, the forehand taking the critical part of the process, where greater skill is demanded. As this proceeds the surface of the melted metal becomes further agitated by the bursting of small bubbles; this agitation, at first superficial, deepens and deepens, until the whole mass is seen to be violently seething and

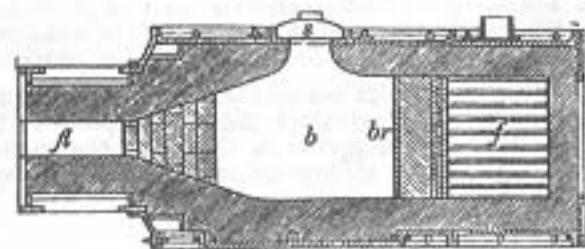


Fig. 9.—Puddling Furnace, horizontal section.

spitting up flashes of blue flame from the bursting bubbles. This flame is mainly due to the burning of carbonic oxide. The puddler calls this the 'boiling,' and now the forehand works the rabble with great energy. As the rabble becomes softened at the working end and heated where held, it is rapidly plunged into a trough of water, and exchanged for a cool one. Careful observation shows that the puddler not only stirs the fluid, but gropes or 'rabbls' along the bottom and sides of the furnace. Presently the melted mass thickens, solid granules are formed amidst the liquid. This the puddler describes as 'coming to nature.' It consists in the separation of infusible iron from the fusible silicates; the oxidation of the silicon forming glassy silicic acid, which combines with oxide of iron or any other basic material within reach. These solid granules are at a welding heat, and the next business of the puddler is to weld them together, which he does by running off as much as possible of the liquid cinder, and squeezing the granules together into a spongy mass or ball. At this stage he lowers his damper and blocks the draught-hole with lumps of coal, in order to envelop the mass of exposed granular iron in a smoky reducing atmosphere. This prevents ruinous oxidation or 'cutting,' as the puddler calls it. Book-learned critics have pointed to the dense volumes of smoke which then issue from his chimney, and have accused him of ignorant wastefulness in the consumption of fuel. In this case the illiterate black-faced puddler understands the theory and the practice of his work, and the learned fine gentlemen are ignorant of both. The ball is now divided into portable dimensions (usually into three), and is rapidly carried to the hammer, where it is struck lightly at first, but with gradually increasing force as it becomes compressed into shape. The three balls may be united, commonly are, and thus beaten into a 'puddled bar.' During this beating, or 'shingling,' liquid cinder is squeezed from the mass like water from a sponge. More and more is squeezed by subsequent compression in passing the puddled bar through rolls similar to those shown in fig. 10. It first enters the large hole of either the square or the round set, and then while still red-hot passes successively through smaller and smaller openings. In the subsequent working of the iron this squeezing out of the impurities is continued. Thus, if it is made into boiler-plates or thin sheets, the bars made by passing through the rolls are cut into short lengths and 'piled'—i.e. stacked in

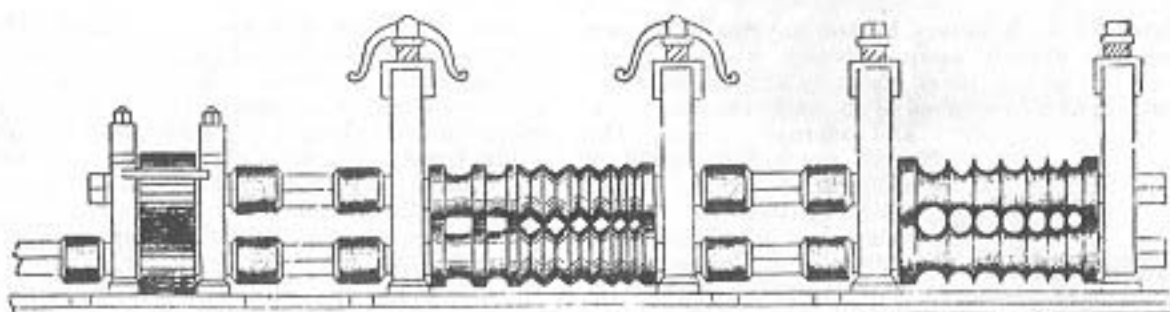


Fig. 10.—Rough and Finishing Rolls.

square bundles, then heated and rolled out, during which working more fluid cinder is expressed. By such means the quality is improved up to a certain point, but beyond this mischief is done, for if the reheating is repeated too often the protecting remainder of carbon is removed, and the iron itself then oxidises—'burnt-iron' is the result. This is friable, owing to the presence of particles of black oxide in the midst of the iron.

Formerly puddling was regarded merely as a process of oxidation produced by the action of air on the surface, and the puddler's stirring was described as a means of bringing fresh material to the surface. It was afterwards shown that large quantities of oxygen are supplied from below by the reduction of the oxide of iron in the fettling. The writer has tested this theory by excessive fettling with rich hematite and laborious rabbling; and has thereby turned out a weight of puddled bar exceeding that of the crude iron of the charge, the excess being due to the reduced iron from the hematite. But even this is not sufficient to account for the purification from sulphur and phosphorus; oxidation alone will not remove the remainder of these when their quantities are brought down to about ½ per cent. This has been fully proved by the failure of the fierce blast of the Bessemer converter to do so without also oxidising the iron itself. The writer's explanation of the puddler's success in purifying very bad pig-iron is that his process consists of oxidation *plus* washing; that he washes the granules of iron in liquid and basic cinder, as the laundress washes fibres of cotton, &c. in soap and water. The sulphur and phosphorus are found in the cinder, as the dirt and grease in the soap-suds. The subsequent squeezing out of the residual entangled liquid cinder by hammering, rolling, &c. is, according to this theory, strictly analogous to the wringing of the laundress. In connection with this impossibility of removing *all* the sulphur and phosphorus by mere oxidation it is desirable to correct a serious error that is repeated in most of our text-books—even the best. This is the statement that wrought-iron contains no practically important quantity of carbon. This error is not shared by practical iron-makers who have studied the chemistry of their work. They know that some carbon or silicon, or both, must remain to protect the iron itself from oxidation when heated. It usually contains about 2 per cent. of carbon, more or less, according to the quantity of silicon, which, being more readily oxidised than carbon, is a still more efficient protector. This is of great practical importance now that the Bessemer and Siemens-Martin processes, formerly used only for making steel, are applied to the manufacture of a malleable iron by pushing the oxidation to its utmost limit. If this limit is exceeded brittleness instead of toughness is the result, and a mistake in this direction involving certain portions of such a structure as the Forth Bridge might be fatal to the whole, as 'nothing is stronger than its weakest part.' For the methods of producing such 'semi-steel,' see BESSEMER STEEL, and STEEL.

Isinglass (supposed to be derived from the German *Hausenblase*, 'bladder of the sturgeon'), the *Ichthyocolla* (ichthys, 'a fish'; kolla, 'glue') of the classical and scientific writers, was formerly obtained only from the common sturgeon (*Acipenser sturio*), and consisted of the dried air-bladder of the animal. The necessities of modern commerce have, however, led to the discovery that the same part in many other fishes forms good isinglass; and instead of Russia, as formerly, being almost the only producing country, large quantities are now brought to Britain from South America (chiefly from Maranhão), some from the East Indies, New York, and Canada. The commercial varieties of this material are numerous: and besides them

others are occasionally met with, as the *Manilla*, in thin cakes; the *Para*, which is the most remarkable of all, resembling grapes of a reddish-brown colour, growing from a straight thick stem, being the dried ova of the *Sudis gigas*, a large fish common in the mouths of the Amazon. An inferior kind is also made of eel-skins and sole-skins, sufficiently good, however, to be used in fining beer and other liquids. Isinglass, strictly speaking, is not Gelatine (q.v.), but a good gelatine-yielding tissue, its value being enhanced by the ease with which it is abstracted from the membrane when compared with the complicated process necessary for separating and purifying the gelatine from the skins, &c. of other animals. When separated, however, the substances are identical in composition, and, if pure, are undistinguishable from each other.

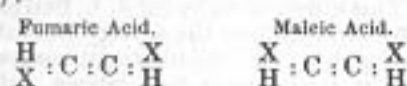
Isomerism (from the Greek word *isomérēs*, 'composed of equal parts'), the relation between chemical compounds which are identical in their ultimate or percentage composition, but present differences in their chemical properties. Isomeric compounds, or *isomerides*, are divisible into metameric compounds, or *metamerides*, and polymeric compounds, or *polymerides*.

In all metameric compounds the molecular weight is the same, while in all polymeric compounds the molecular weights are simple multiples of the molecular weight of the lowest member of the group. As an illustration of metamerides, propionic acid, $C_2H_5 \cdot CO \cdot OH$, acetate of methyl, $CH_3 \cdot CO \cdot OCH_3$, and formic ether, $H \cdot CO \cdot OC_2H_5$, may be taken. Their rational formulæ, which express their probable constitution, are perfectly distinct, yet they all have the same percentage composition, the same empirical formula, $C_3H_6O_2$, and the same molecular weight (74).

As an illustration of polymerides, the hydrocarbons homologous with olefiant gas may be taken. Olefiant gas is represented by the formula C_2H_4 , propylene by C_3H_6 , butylene by C_4H_8 , amylene by C_5H_{10} . These substances have the same percentage composition, but different molecular weights.

The carbohydrates, which are represented by the general formula $C_nH_{2n}O_n$, present well-marked examples of isomerism. Thus, cellulose, $C_6H_{10}O_5$, starch, $C_6H_{10}O_5$, and gum, $C_6H_{10}O_5$, are metameric; while grape-sugar, $C_6H_{12}O_6$, possesses the same percentage composition, but twice as high a molecular weight, as lactic acid, $C_3H_4O_3$, and the same percentage composition, but three times as high a molecular weight, as acetic acid, $C_2H_4O_2$; hence the three last-named substances are polymeric.

The most recent researches have brought to light the existence of several special varieties of isomerism. A *tautomeric* body is one in which the reaction to some reagents is as if certain hydrogen atoms were in one place in the molecule, while to others it is as if the hydrogen occupied a different position; and a tautomeric body may be *desmotic* when it can be prepared in recognisably different forms, differing from one another in the position of these wandering hydrogens. *Alloisomeric* bodies have a similar chemical structure, but the geometrical symmetry is different, as in the following case (in which the symbol X stands for the group $\cdot CO \cdot OH$):



The question of geometrically symmetrical or asymmetrical arrangement of atoms in a molecule has become, in the hands of Wislicenus and others, one of considerable importance in reference to isomerism. Quite possibly the allotropic modifications of some of the elements (see ALLOTROPY) are really isomeric differences of arrangement of the

atoms within the Molecule (q.v.). See also AROMATIC SERIES and CHEMISTRY.

Isomorphism (derived from the Greek words *isos*, 'equal,' and *morphe*, 'form') strictly signifies similarity of form, but it is now restricted by chemists to those substances which are not only similar in their crystalline form, but are also analogous in their chemical composition. The diamond, C, magnetic oxide of iron, $\text{FeO}, \text{Fe}_2\text{O}_3$, and potash-alum, $\text{K}_2\text{SO}_4, \text{Al}_2(\text{SO}_4)_3, 24\text{H}_2\text{O}$, all crystallise in octahedra, but there is obviously no analogy in the chemical composition of these substances; on the other hand, the spinelle ruby, $\text{MgO}, \text{Al}_2\text{O}_3$, magnetic oxide of iron, $\text{FeO}, \text{Fe}_2\text{O}_3$, and chrome ore, $\text{FeO}, \text{Cr}_2\text{O}_3$, not only crystallise in octahedra, but (as their formulae show) are also analogous in their chemical composition. Hence the members of the latter group, not the former, are truly isomorphous in the restricted sense. As further examples we may quote the elements arsenic, antimony, and tellurium; the chloride, bromide, iodide, and fluoride of potassium; the sesquioxides of aluminium, iron, chromium, and manganese; and for additional lists refer to Miller's *Chemical Physics*. In most cases, as Mitscherlich (to whom we owe most of our knowledge of this subject) showed, the chemical composition of substances that correspond in form is analogous; and that chemist further endeavoured to prove that crystalline form is independent of the chemical nature of the atoms, and that it is determined solely by their grouping and relative positions; the same number of atoms combined in the same way always producing, according to him, the same crystalline form. The coincidence of similarity in crystalline form with similarity in atomic arrangement is the most important generalisation yet arrived at in the science of crystallography; and in chemistry it has been of essential service in facilitating the classification of compounds, and to some extent in determining the combining numbers or atomic weights of the elementary bodies.

Itch, or **SCABIES**, a skin disease produced by a minute mite (*Sarcoptes scabiei*), which burrows in the epidermis of most parts of the body, but especially about the hands. Its presence is marked by a small scaly elevation of the skin, by eruptions as the papillae of the cutis are perforated, and by the irritating itching sensation.

The mite itself is white or yellowish, broad and flat, with two pairs of mouth parts, and four pairs of appendages. The males are scarcer and much smaller than the females, which are just visible to the naked eye. When they have entered the skin they do not leave it, but form tortuous burrows, through openings in which the embryos escape. The mites are passed by contagion from person to person, either by direct contact or by clothes or bedding. It is probably the embryos or larvae which are usually thus transmitted. The above species also occurs on the horse, Neapolitan sheep, and lion; *S. squamiferus* occurs (causing mange) on dogs, pigs, goats, sheep, and apparently also for a short period on man; *S. minor* is also distinguished on cats and rabbits.

The itch was for a while regarded as a specific disease, the mite being unknown. Avenzoar, an Arabian physician of the 12th century, is said to have recognised its true nature. So does Scaliger (1557); and Adams figures the animal in a paper read in 1805 before the Royal Society. Amid some scepticism as to the mite during the early part of this century, M. Gales hoaxed the public by figuring as a substitute for the itch-mite the familiar denizen of cheese. His trick was discovered by Raspail, and the existence of a real mite was more distrusted than ever, till in 1834 Renucci, a Corsican student, again demonstrated its presence and characters. It has been often studied since.

The usual cure for itch is found in baths, with abundant soap, or in rubbing with sulphur ointment. If these be not resorted to, the multiplication of the mite may give more serious trouble.



Itch-mite:
Abdominal view of female
itch-mite, magnified 65
diameters.

Japanning is the art of producing, by the aid of heat, a hard coating of coloured varnish upon metal, wood, or papier-maché. Articles so coated resemble the lacquer wares of Japan and China (see LACQUER). A japanned surface differs from an ordinary painted surface in being harder and more durable, and also in not being easily injured by hot water or by being placed near a fire. A good brown 'japan' is prepared by separately heating equal quantities of amber and asphaltum, and adding to each one-half the quantity by weight of boiled linseed-oil. Both compounds are then mixed together. Copal resin may be substituted for the amber, but it is not so durable. Tinned iron goods are most largely japanned, and for them brown and black colours are chiefly used. Both are obtained by the use of brown japan, the metal getting a preliminary coating of black paint when black is required. Only one coating of brown japan is given to cheap goods, but for better wares two or more coatings are applied. After each coating the articles are heated for ten or twelve hours in an oven at from 135° to 165° F., or even up to a much higher temperature. The japanned surface is then rubbed with fine ground pumice, next with rottenstone, and the final polish given to it by the palm of the hand. Gold or bronze bands or floral decoration, or both, are generally added. These are first painted on in japanner's gold size, and then the gold leaf is applied or the bronzed powder dusted on, after which the objects are again placed in the oven. After they are removed the gilt or bronzed portions get a protecting coat of white spirit varnish. When white or other light colours are used for japanning they are mixed with japanner's varnish. These require more careful heating in the oven than dark brown or black. Such articles as tea-trays, coal-boxes, cash-boxes, tin canisters, and the like are japanned in great numbers in Birmingham. Portable baths are usually finished internally in white japan; and it may be remarked that this would last much longer than it often does if care were taken not to leave soapy water in the baths after being used. The varnishing or japanning of the surface of papier-maché wares is a similar process to the above, but in the case of these shell or metal inlaying is often worked into the japan.

Jute and Jute Manufactures. Some attempts on a small scale to utilise jute-fibre for the manufacture of carpets were made at Abingdon, in Oxfordshire, about the year 1820 or soon after it. But it was at Dundee, which had long been one of the principal seats of the linen industry, that, in 1832 or 1833, the spinning and weaving of jute first began to give promise of commercial success. The fibre, then little known in Europe, was at first received with suspicion, and for some years it was slowly and somewhat stealthily introduced as a textile material. By the year 1850,



Jute (*Corchorus capsularis*):
a, flower; b, fruit.

however, the use of jute had become extensive, and since then, owing, among other things, to the improvements in preparing and spinning machinery, the manufacture of this fibre has rapidly extended, and is now carried on at Dundee, the chief seat of the industry, on a gigantic scale. Jute cloth for gunny-bags (q.v.) and for native clothing has long been woven on hand-loom in Bengal, where the plants yielding the fibre are cultivated. Since 1857 a number of large jute-mills, fitted up with textile machinery, driven by steam-power, have been erected in the neighbourhood of Calcutta. The comparatively small cost at which jute can be raised and manufactured will no doubt secure its permanent success as a textile

industry; but the fibre is decidedly inferior to flax in strength and especially in durability.

Jute is obtained from the bark of two closely-allied species of plants belonging to the lime-tree order (Tiliaceae). One species, *Corchorus capsularis*, is cultivated in central and east Bengal; the other, *C. olitorius*, is grown, but to a more limited extent, in the neighbourhood of Calcutta. The former grows from 5 to 10 feet, sometimes even to 14 feet, in height, but the latter is rather a smaller plant. The chief difference between the two is in the form of the fruit, which in *C. capsularis* is globular, and in *C. olitorius* much elongated. Both are annuals with yellow flowers, and they can be best cultivated on a loamy soil or upon one of clay and sand. The higher lands produce the finest qualities of jute. Such as is grown upon mud-banks or upon submerged lands is mostly larger and coarser. The sowing time, which is regulated by the nature and position of the soil, extends from March to June. When the plants flower, which they do in some places in the end of June, the cutting of the crop begins, but this is often not done till the fruit is formed. The harvest is not entirely finished till October, and it is from late reaping, with the plants in seed, that coarse jute is obtained, the crop yielding the best fibre if cut during the flowering period.

The fibre, which is the inner bark, is separated from the stem by retting—i.e. steeping in water (see FLAX). Sometimes the jute is placed in rivers, but more generally in tanks or stagnant pools. To prevent any risk of discoloration of the fibre in the process the jute stalks in some districts are first stacked for a few days to allow the leaves to decay. According to the nature of the water used and the character of the crop, the period of retting lasts from two days to fully three weeks. Care must be taken to stop the process as soon as the fibre begins to separate from the stem, otherwise it rapidly deteriorates. It is believed that retting weakens the fibre, and that if it could be separated from the bark by some inexpensive mechanical process a better quality of jute than it is now possible to obtain would be sent into the market.

The best qualities of jute are of a pale clear yellow or buff colour, with a silky lustre, easily spun and comparatively strong. But there are at least half a score of well-known commercial varieties. Some are bright-coloured, soft, and strong, and such are best for textile fabrics—i.e. comparatively soft, for all jute is of a hard and woody nature. Other kinds are coarse and strong, and suited for making ropes. One or two varieties which are of weak fibre are suited for making paper. One kind, which is long, soft, and fine, but of bad colour, is largely used for gunny-bags.

In order to lessen the harsh and brittle character of jute it is subjected to a softening process on a kind of crushing mangle, from cisterns attached to the top of which oil and water are at the same time sprinkled evenly upon it. Formerly whale-oil was used for this purpose, but of late years a heavy paraffin oil or some similar mineral oil has been largely substituted for it, a change which caused a great fall in the price of whale-oil. The mangle consists of four horizontal rows of fluted rollers, 9 inches in diameter, between which the jute passes in a continuous layer, entering at one end between the first pair of the two upper rows, and coming out at the opposite end between the last pair of the two lower rows. Besides simply turning round, the rollers have also a slight lateral motion, so that the jute is thoroughly crushed or nipped. This crushing—together with the help of the oil and water—softens the fibre, and prepares it for the spinning processes.

Jute was formerly, and to a small extent is still, spun by two distinct processes, called 'line' spinning and 'tow' spinning, which correspond to those in use for flax. The main difference between them is that in 'line' spinning the fibre is heckled on machines with heckle-stocks furnished with steel teeth, which dress and separate the line or best part of the fibre

from the tow, or least valuable portion. In the 'tow' spinning the fibre is first carded on carding-engines, each of which has a peculiar arrangement of revolving cylinders, armed with card points or pins of steel wire. What may be called the carding process of spinning is no longer confined to jute tow, but the whole of the jute is now, as a rule, spun on this system—i.e. it is not heckled at

all. Jute-fibre as obtained from the plant being from 6 to 7 feet long, and often considerably more, it requires to be broken into lengths of from 14 to 18 inches. This is done on the machine called the breaker-card, upon which also the jute is cleaned and the fibres laid more or less parallel by the action of the card points. The jute leaves the breaker-card in the form of a continuous lap or sliver, 3 to 4 inches broad, and fifteen of these are drawn out and delivered as a single sliver by the second carding engine, called the finisher-card. This attenuation is accomplished by the doffing-rollers having fifteen times the surface speed of the feed-rollers.

The sliver, or rather slivers, are next taken to the drawing-frame, where their fibres are further straightened and equalised. The drawing-frame has feed-rollers, travelling gills with steel teeth, and drawing and delivery rollers. Here four slivers from the finisher-card are caught by the feed or retaining rollers, passed through the travelling gills, and drawn out into one sliver by the drawing-rollers, which, as well as the delivery-rollers, move at $\frac{1}{4}$ times the speed of the retaining-rollers. The sliver from the drawing-rollers is, besides, usually doubled by passing two of them between the delivery-rollers. The process is repeated on a second drawing-frame with finer and closer teeth than those on the gills of the first. The object of doubling and drawing out the slivers so frequently is that the thick place of one sliver may be corrected by the thin place of another, and also that the different kinds of jute may be thoroughly mixed both as to quality and colour.

Roving is the next operation, and the roving-frame in the arrangement of its rollers and gills is similar to the drawing-frame, but in the former the parts are smaller and the gill-teeth finer and more closely set. As the sliver on this machine, after being still further attenuated by drawing-out rollers, requires to be twisted into a loose thread or 'rove,' a spindle and flier are provided, as well as a bobbin upon which to wind it. Finally the bobbins of 'rove' are taken to the spinning-frame, and spun into yarn upon the 'throstle' principle. See SPINNING.

Jute fabrics are for the most part woven of yarn retaining its natural colour. But for some purposes it is bleached, and when used for carpets or curtains it is dyed various colours. Although it can only be made pure white with difficulty, it readily bleaches pale enough to admit of its being dyed without injury even to bright colours. Dyes upon jute are, however, fugitive unless they are dyed by a special and expensive process, which is only carried out to a small extent in practice. At Dundee the ordinary fabrics made of jute are Hessians, sackings, carpets, tarpauling, and backings for floorcloth. The last-named are woven on looms of extraordinary width (see FLOOR-CLOTH). Dyed carpets, curtains, table-covers, and the like, of this material, are attractive enough in appearance, and carpets especially are largely made. These are cheap but not very durable. Millions of small, brightly-dyed prayer carpets for Moslems are sent from Dundee to the East. Fabrics made of jute are easily rotted by damp, and cannot be often washed and dried like linen or cotton goods without injuring them. This fault of jute soon betrays itself if it is mixed with flax for towelling. Jute, from its somewhat glossy lustre, is occasionally used to sophisticate silk; and it has been employed to some extent to make wigs and other articles in imitation of those made of human hair, chiefly for theatrical purposes.

Kaleidoscope (from Gr. *kalos*, 'beautiful,' *eidos*, 'image,' and *skopeo*, 'I see'), an optical instrument invented by Sir David Brewster in 1817. It consists, in its simplest form, of a tube, through whose whole length pass two mirrors or reflecting planes, which are hinged together along one edge, and make with each other an angle which is an aliquot part of 180° , whilst the one end is fitted up with an eyeglass, and the other is closed by two glasses, at a small distance from each other, between which are placed little fragments of glass or other variously-coloured objects. The eye looking into the tube now perceives these objects multiplied as many times as the angle which the reflecting planes make with each other is contained in the whole circumference of a circle, and always symmetrically disposed; and the slightest shaking of the instrument produces new figures. There are various modifications of

the kaleidoscope, by some of which its power is much increased; for example the mirrors may be adjustable at various angles measured with respect to a variably distant centre, so that arched patterns may be obtained; and it is not only a pleasing toy, but is sometimes used by pattern-drawers and others, to whom it supplies endless varieties of figures.

Kaolin, or CHINA CLAY, is fine white clay used in making porcelain. Like less pure clays, it is essentially a hydrous silicate of alumina, but it is a comparatively rare substance. The clays found in most localities contain iron in sufficient quantity to colour them red or buff when burned in a kiln, but China clay is of a pure, or nearly pure white both before and after it is fired. This, together with its refractory nature, makes it of great value in the manufacture of porcelain, of which it forms the chief ingredient. It is also used to a considerable extent by paper-makers, and in less quantity in the making of some chemical products. Kaolin is a product of the decomposition of the felspar of a granitic rock. The name Kaolin is derived from the Chinese *Kao-ling*, 'high ridge,' the name of hills near King-tih-chin in Chiang-hsi, a chief seat of the porcelain manufacture in China. Clay from this district was sent to Europe early in the 18th century by Jesuit missionaries; similar clay was discovered in Saxony; and about 1755 it was discovered in Cornwall, whence the chief English supplies are obtained, some being also obtained in Devonshire—in all, about 30,000 tons a year. Kaolin is found in France, and in Nebraska and other states of the American Union;

Kelp (Fr. *varvch*) is the crude alkaline matter produced by the combustion of seaweeds, of which the most valued for this purpose are *Fucus vesiculosus*, *F. nodosus*, *F. serratus*, *Laminaria digitata*, *L. bulbosa*, *Himanthalia lorea*, and *Chorda filum*. These are dried in the sun, and then burned in shallow excavations at a low heat. About 20 or 24 tons of seaweed yield one ton of kelp. The kelp met with in commerce consists of hard, dark-gray or bluish masses, which have an acrid, caustic taste, and are composed of chloride of sodium, of carbonate of soda, sulphates of soda and potash, chloride of potassium, iodide of potassium or sodium, insoluble salts, and colouring matter. It used to be the great source of soda (the crude carbonate); but, as this salt can now be obtained at a lower price and of a better quality from the decomposition of sea-salt, it is prepared in far less quantity than formerly from kelp. A ton of good kelp will yield about 8 lb. of iodine, large quantities of chloride of potassium, and additionally, by destructive distillation, a large quantity of volatile oil, from 4 to 15 gallons of paraffin oil, 3 or 4 gallons of naphtha, and from $\frac{1}{2}$ to 4 cwt. of sulphate of ammonia.

Kidneys, two glands having for their function the excretion of the urine. The human kidneys are situated in the region of the loins, one on each side of the spine, and are imbedded in a layer of fatty tissue. Their form is distinctive. They possess a convex outer border and a concave inner border, the extremities are somewhat enlarged, and the organ as a whole is compressed from before backwards. The average length of each kidney is a little more than 4 inches, and its usual weight is from 4 to 6 ounces. The left kidney is longer and narrower than the right, and in the female the weight is slightly less than in the male. The concave inner border presents a longitudinal fissure—the hilum—at which the vessels enter; in front there is the renal vein, behind it the renal artery, and most posterior the ureter, which conveys the urine to the bladder. When the sides of the hilum are held apart a deep indentation is seen—the sinus of the kidney

—in which the ureter dilates to form a large sac, the pelvis of the kidney. Investing the kidney there is a fibrous coat—the *tunica albuginea*—which readily peels off from the substance of the gland to which it adheres by minute processes and fine blood-vessels. At the hilum it turns inwards, and becomes continuous with the sheath of the vessels. Under cover of this capsule there is an incomplete layer of involuntary muscular fibre. The substance of the kidneys is dense, extremely friable, and of a deep red colour. On making a longitudinal section of the kidney from the convex outer border to the hilum it is seen to consist of two different substances, which are named, from their position, the external or cortical and the internal or medullary substance, arranged in pyramids with their apices towards the hilum.

The *cortical substance* forms by far the greater part of the gland, and sends numerous prolongations inwards between the pyramids of the medullary substance. It is soft, granular, and contains numerous minute red globular bodies diffused throughout it, which are called, from their discoverer, the Malpighian bodies. Its substance is made up of the *uriniferous tubes*, capillaries, lymphatics, and nerves, held together by an intermediate parenchymatous substance.

The *medullary substance* consists of pale reddish, conical masses, called the pyramids of Malpighi. They are usually about twelve in number, but vary from eight to eighteen, and their apices (the *papillæ*) point towards the hollow space (termed the *sinus* or *pelvis*) which occupies the interior of the gland. The medullary structure is firmer than the cortical, and instead of being granular presents a striated appearance, from its being composed of minute diverging tubes (the *uriniferous tubes*), which run in straight lines through this portion of the kidneys, after having run in a highly-convoluted course through the cortical portion. From the base of each pyramid streaks pass through the cortex, named *medullary rays*, and the portions of cortical substance between the rays are called the *labyrinth of the cortex*.

The cavity occupying the interior of the kidneys (the *sinus* or *pelvis*) is lined by mucous membrane, which, through the medium of the ureter, is continuous with that of the bladder, and which extends into the tissue of the kidneys, to line the uriniferous tubes. The mucous membrane forms a cup-like cavity around the termination of each pyramid, and the cavity, termed the *calyx*, receives the urine from the open terminations of the tubes, and conveys it towards the pelvis, from whence it passes down the ureter into the bladder.

Each kidney is supplied with blood by a renal artery, a large trunk which comes off at right angles to the aorta. The blood, after the separation of the various matters which constitute the Urine (q.v.), is returned into the venous system by the renal or emulgent vein, which opens into the inferior vena cava. The nerves are derived from the renal plexus.

The Malpighian bodies are found in all vertebrate animals. In mammals, which are the only animals in which there is a division into a cortical and a medullary portion, these bodies are only found in the former. They are for the most part of a spherical, oval, or flask-like form. Their diameter in man may range from $\frac{1}{16}$ to $\frac{1}{12}$ of an inch, the mean being $\frac{1}{17}$. A small artery, termed the *afferent vessel*, may be traced into each Malpighian body, while a minute venous radicle, the *efferent vessel*, emerges from it close to the point at which the artery had entered. The Malpighian body itself, situated in the labyrinth, consists of a rounded bunch or tuft of capil-

Fig. 1.—Vertical Section of Kidney:

a, supra-renal capsule; bb, cortical substance of kidney; cc, medullary substance of kidney; dd, tunica albuginea; eee, the sinus or pelvis; f, the ureter, proceeding to the bladder.

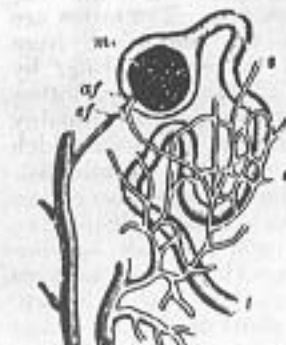


Fig. 2.—Plan of the Renal Circulation in Man and the Mammalia (from Ludwig):

a, terminal branch of the artery, giving the terminal twig, af, to the Malpighian tuft, m, from which emerges the efferent vessel, ef. Other efferent vessels, e, e, e, are seen proceeding from other tufts, and entering the capillaries surrounding the uriniferous tube, t. From this plexus of capillaries the emulgent vein, eo, springs.



laries, derived from the afferent and terminating in the efferent vessel, and enclosed in a clear and transparent capsule—the capsule of Bowman—lined with flattened epithelium. Each capsule is continuous with the uriniferous tube by a narrow neck.

It now remains to consider the respective functions of the Malpighian bodies and the tubes. From the researches of Bowman and others it appears that in animals in which the urinary excretion is passed in an almost solid form (as in birds and reptiles) the tufts are small and simple as compared with those in the kidneys of animals which (like man and most mammals) pass the urinary constituents dissolved in a large quantity of water. On these grounds, as well as from the fact that the anatomical arrangement of the tufts is well calculated to favour the escape of water from the blood, Bowman arrived at the conclusion that the function of the Malpighian bodies is to furnish the fluid portion (the water) of the urine. Recent observations tend to show that the saline ingredients of the urine are also excreted by Bowman's capsule. The arrangement of the convoluted portion of the tubes, with a capillary network on one side of their basement membrane, and secreting epithelial cells on the other, is the exact counterpart of the arrangement in other secreting glands, and there can be no doubt that the functions of the cells in the convoluted portion of the tubes is to separate from the blood the various organic constituents (urea, uric acid, creatinine, &c.) which collectively form the solid constituents of the urine. It does not necessarily follow that these secreting cells undergo rapid decay and renewal; it is more probable that they have the power of selecting certain materials from the blood, and of transmitting them, without the disintegration of their own structure, to the interior of the tube. The physical and chemical characters of the secretion yielded by the kidneys will be considered in the article URINE.

DISEASES OF THE KIDNEYS.—By far the most important are the group included under the general name of Bright's disease, which may be defined as comprising cases where structural changes in the kidneys, usually inflammatory, but without suppuration, lead to the presence of albumen in the urine. Dr Richard Bright published in 1827 researches showing that many cases of dropsy are attended by albuminuria on the one hand, and by marked changes in the kidneys on the other. His observations have been confirmed and extended by many subsequent observers; and it is now agreed that there are three distinct groups of cases, differing much in causation, symptoms, course, and post-mortem appearances, to which the above definition applies. These must be considered separately.

(1) *Catarrhal or Parenchymatous Nephritis* (inflammation of the kidneys).—In this form the inflammation affects chiefly the secreting structures of the kidney—i.e. the cells lining the tubules. The kidneys are at first much enlarged; in acute cases in the early stage redder than in health; in later stages and in chronic cases paler. If the duration of the disease is long, however, they may ultimately become much diminished in size, so as much to resemble, except in their paler colour, the kidneys in the cirrhotic form of Bright's disease. This disease may often be traced to exposure to cold; frequently complicates pregnancy; and occasionally occurs in connection with most of the eruptive fevers, but particularly scarlet fever, of which it is one of the most common and serious complications. In acute cases it sometimes begins with a rigor and elevation of temperature. Dropsy is almost always one of the earliest symptoms, and often appears first in the skin of the eyelids. Pain

in the region of the kidneys, headache, and vomiting are usually present. The urine is scanty, often bloody, and contains albumen and tube-casts. Symptoms of Uremia (q.v.) often occur. In favourable cases complete recovery takes place in the course of a few weeks, all the symptoms gradually subsiding. Frequently, however, though the severer features of the case disappear, the urine continues to contain albumen, and the disease becomes chronic. Death may result from uræmia, from dropsical effusion, especially in the large serous cavities, frequently from the occurrence of some acute inflammation, particularly of lungs, pleura, or pericardium.

(2) *Cirrhosis of the Kidneys, or Interstitial Nephritis.*—In this form the morbid process consists chiefly in chronic inflammation of the connective tissue of the kidney, which leads to destruction of the tubules and glomeruli by cicatricial contraction. In advanced cases the kidneys are much diminished in size, rough and nodular on the surface, and red in colour. This disease is often traceable to gout, either inherited or acquired, or to chronic lead-poisoning. It is rare before the age of thirty, most common after forty or forty-five. The

chief feature of this affection is its extremely chronic and insidious nature, which is so marked that it is almost always for some secondary result of the disease that the patient seeks medical advice, and not for symptoms directly referable to the kidneys. The earliest symptom is usually an increase in the quantity of urine, which contains albumen only in small quantities, and may sometimes be quite free from it. Hypertrophy of the heart, with a hard pulse, is one of the most constant features of the disease; and in many cases symptoms due to heart affections are the first which excite the patient's alarm. Persistent headache, unaccountable vomiting or diarrhoea, failure of sight owing to albuminuric retinitis, simple debility, symptoms of uræmic poisoning, cerebral hæmorrhage (apoplexy), or the occurrence of acute inflammation of some internal organ—all these are among the occurrences which may lead to the discovery of this singularly insidious disease. It frequently becomes complicated by addition of inflammation of the kidney tubules (above described) to the primary process, and the symptoms are modified accordingly.

(3) *Waxy or Lardaceous Degeneration of the Kidney.*—As when this degenerative process appears in other organs, the smaller arteries and capillaries are first and most affected; later, other portions of the organ partake in the morbid process. But in the great majority of cases some degree of inflammation of the tubules is also present. Like waxy degeneration elsewhere, it can almost always be traced either to syphilis or to prolonged suppuration. The flow of urine is generally increased in the early stage, and contains albumen. Dropsy is usually present, with some others of the symptoms enumerated above as characteristic of the first form of Bright's disease. But in general the symptoms are rather variable, and could hardly lead to the recognition of the condition present apart from the clue given by the previous history of the case and the occurrence of signs of waxy disease in other organs. In acute cases (first form) prompt and active treatment is necessary, and is often signally successful. Confinement to bed between blankets, light diet, mainly or exclusively of milk, and the production of very free action of the skin and bowels are usually the chief points to be attended to. In the most severe cases wet-cupping or bleeding from the arm is sometimes required. Extreme care is necessary till perfect recovery has taken place. In chronic cases warm clothing, with attention to the action of the skin, strict regulation of the diet, avoidance of alcohol, and where possible removal to a warm climate during the cold season can do much to keep the disease in check. Experience has shown that under favourable conditions the course of the disease may be much more gradual than was generally believed by physicians thirty years ago.

Albuminuria without Bright's disease may occur in the course of fevers, in heart disease, and many other morbid conditions. It is now believed by most observers, though the subject is still under discussion, that it may also be present without any actual disease. *Hæmoglobinuria* (impregnation of the urine with the colouring matter of the blood) is a troublesome, but, except in the case of infants, not a dangerous disease. *Hæmaturia* (blood in the urine) is indicative of disease in

some part of the urinary passages; but it is often difficult to be certain what portion is at fault. Besides Bright's disease, the most common condition leading to it is stone in the kidney or bladder. For *Glycosuria* (sugar in the urine) and *Polyuria* (increase in the quantity of urine), see DIABETES.

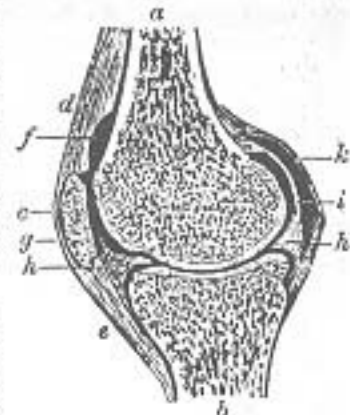
Stone in the Kidney.—The symptoms attending the passage of a stone from the kidney to the bladder have already been described (see CALCULUS); but it not infrequently happens that a stone formed in the kidney remains there, or, though it enters the ureter, fails to escape, blocking it and preventing the discharge of urine from that kidney. In either case the symptoms are often somewhat obscure and difficult to trace to their true cause. When the stone remains in the kidney blood generally appears from time to time in the urine, and there is persistent pain in the loin, often aggravated by such movements as the jolting of a carriage. Medicinal and dietetic treatment may often prevent the formation of fresh stones, where one has been discharged; and sometimes even seems to lead to the removal by solution of a stone from the kidney. Operation has frequently been resorted to during recent years for the removal of a stone from the kidney, and has in some cases relieved the symptoms, even when no stone has been discovered. When a stone becomes impacted in the ureter the kidney is gradually destroyed, and either atrophies or becomes converted into a large sac containing fluid. The remaining kidney generally becomes enlarged, and carries on the function of excretion; but if its ureter subsequently becomes obstructed in the same way death rapidly ensues.

Suppurative inflammation of the kidney may occur in the course of pyæmia, but usually results from disease of the lower urinary passages (bladder or urethra, hence often called surgical kidney), and is a very fatal disease. The kidneys may become the seat of tubercular disease, of malignant tumours, of hydatid cysts. But none of these conditions are of common occurrence.

Floating or Movable Kidney.—One kidney, more rarely both, may have its attachments to the posterior wall of the abdomen so loosened and elongated that it can move about in the abdominal cavity, somewhat as the intestines normally do. This condition is much more common in women than in men, and may either produce no symptoms, or lead to great discomfort and distress. In the latter case it is usually possible so to adapt a bandage and pad as to restrict the movements of the organ and to relieve the symptoms.

Knee, the articulation between the femur or thigh-bone, above, and the tibia or shin-bone, below. A third bone, the patella, or knee-cap, also enters into the structure of this joint anteriorly. The articular surfaces of these bones are covered with cartilage, and connected together by ligaments, some of which invest the joint and lie external to it, while others occupy its interior. The synovial membrane is the largest in the body. It lines the investing ligament, and is prolonged on the front of the femur above the articular surface, covers certain of the ligaments in the interior of the joint, and forms folds on a large cushion of fat placed between the tibia and patella.

The most important of the external ligaments are the anterior or *Ligamentum Patellæ*, which is in reality that portion of the *Quadriceps Extensor Cruris* which is continued from the knee-cap to the tubercle of the tibia; one internal and two external lateral ligaments; a posterior ligament; and a capsular ligament, which surrounds the joint in the intervals left by the preceding ligaments. The positions of these ligaments are sufficiently indicated by their names. Of the internal ligaments the two crucial, so called because they cross one



Vertical Sagittal Section through the inner half of the Left Knee (from Macalister):

a, femur; b, tibia; c, patella; d, tendon of quadriceps muscle; e, ligamentum patellæ; f, subcrural bursa; g, prepatellar bursa; h, internal semilunar cartilage; i, ligamentum posticum; k, inner head of gastrocnemius.

another, are the most important. The external and internal semilunar cartilages are usually placed amongst the internal ligaments; they are two crescentic plates of fibro-cartilage. The convex border of each cartilage is thick; the concave free border is thin. Each cartilage covers nearly the marginal two-thirds of the corresponding articular surface of the tibia, and by its form deepens these surfaces for firmer articulation with the condyles of the femur.

The chief movements of this joint are those of a hinge-joint—namely, flexion and extension; but it is also capable of slight rotatory motion when the knee is half-flexed. During flexion the articular surfaces of the tibia glide backwards upon the condyles of the femur; while in extension they glide forwards. The whole range of motion of this joint, from extreme flexion to extreme extension, is about 135° . Judging from its articular surfaces, which have comparatively little adaptation for each other, it might be inferred that this was a weak and insecure joint; and yet it is very rarely dislocated. Its real strength depends on the large size of the articular ends of the bones, on the number and strength of the ligaments, and on the powerful muscles and fasciæ by which it is invested. See JOINTS, where also the excision of the knee-joint is discussed.

The KNEE-CAP, or PATELLA, is a Sesamoid Bone (q.v.), developed in the single tendon of the *rectus, crureus, vastus externus, and vastus internus* muscles—the great quadriceps extensor muscle of the leg. It is heart-shaped in form, the broad end being directed upwards, and the apex downwards. The anterior or external surface is convex, perforated by small apertures for the entrance of vessels, and marked by rough longitudinal striæ; the posterior or internal surface is smooth and divided into two facets by a vertical ridge, which corresponds and fits into the groove on the lower articulating surface of the femur or thigh-bone, while the two facets (of which the outer is the broader and deeper) correspond to the articular surface of the two condyles.

This bone is liable both to dislocation and fracture. Dislocation may occur either inwards or outwards; but it is most frequent in the outward direction. The displacement may be caused either by mechanical violence, or by too sudden contraction of the extensor muscles in whose conjoint tendon it lies; and is most liable to occur in knock-kneed, flabby persons. Except in one rare variety, the dislocation is capable of being reduced without any difficulty. Fracture of the patella may, like dislocation, be caused either by muscular action or by mechanical violence.

Fracture by violent muscular action, as when a person in danger of falling forwards attempts to recover himself by throwing the body backwards, is the more common of the two forms. The treatment consists in relaxing the opposing muscles by raising the trunk, and slightly elevating the limb, which should be kept in a straight position. In consequence of the great difficulty of bringing the broken surfaces into exact apposition it is very difficult to obtain bony reunion of the parts, and the case generally results either in mere ligamentous union or in no true union at all.

Lac, best known in the form of shell-lac, is a coloured resinous substance of great importance in the arts. It is produced by a small insect—from $\frac{1}{16}$ th to $\frac{1}{8}$ th of an inch in length—called *Coccus lacca* (*Carteria lacca* of Signoret), belonging to the sub-order Homoptera of the Hemiptera, or Bugs. Lac is found in India, Burma, Siam, China, and in some of the islands of the Eastern Archipelago. The lac-insect lives upon the young branches of many different species of trees, but the best lac is collected from two or three species of fig, *Zizyphus* and *Butea frondosa*.

As soon as the young are hatched they crawl about in search of sappy twigs. To these they fix themselves by their proboscides, and immediately begin to form their lac cells or cocoons. These have one anal aperture and two others for the admission of air, and in their cocoons the insects remain in a lethargic state for two and a half months. The females, which greatly outnumber the males, never leave the spot to which they attach themselves, but the males escape by a ventral opening in the cocoon. After impregnation the female feeds voraciously on the juice of the twig to which it is fixed, increases in size, and continues to form lac. The lac surrounds all parts of the insect except the mouth and the three apertures already mentioned. When the young are

perfectly formed they issue by the anal opening in the lac incrustation. Naturalists are divided in opinion as to whether the lac is secreted by the insect itself, or whether it is not merely the resinous juice of the trees altered in character by the insect while making its puncture, or just after it is made.

The appearance of the incrustation varies. It often takes the form of coalesced rounded prominences, at some places surrounding, at others scattered over, the branches; but in other instances it looks, superficially, more like a thick, irregular outer layer of bark roughened on the surface. The incrustation is cellular, each cell indicating the position of the insect which formed it. *Stick-lac* is the name given to it when the incrustation is still attached to the twigs, which are usually cut into pieces from three to six inches long. The next step is to remove the lac by a roller moving on a platform, the detached fragments being afterwards placed in tubs of water, and beaten by pestles or trodden by men. It is now in the state of *seed-lac*. The water left in the tubs is coloured red by the bodies of the insects, and, after this water is evaporated, the red substance is made into cakes, forming the lac-dye of commerce (see DYEING). After drying the seed-lac is melted in cylindrical cotton bags before charcoal fires, and, by twisting the bags, forced through the pores of the cloth. It drops into troughs, and is either allowed to spread out itself, or is spread by a strip of leaf upon a roller, into a thin sheet. After the impurities are broken out, the flakes are packed in bags, forming the *shell-lac* of commerce. Another form is *button-lac*, which is made by letting the melted lac drop into rounded pieces from 1-1½ inches in diameter.

In India a good deal has been done in the cultivation of lac by transporting the encrusted branches to suitable forests about a fortnight before the young insects begin to move about. The twigs with the insects in the larval state are tied on branches of trees which have been selected for the rearing of future broods. The inland trade for the year 1889 was valued at 101 lakhs of rupees.

Lac has many industrial applications. Shell-lac varnish is more extensively employed than any other spirit varnish. One variety of it is French Polish (q.v.) for furniture (see also LACQUER). Lac applied as an alcoholic solution is used to stiffen the calico frame of silk hats (see HAT). In fine sealing-wax it is the most important ingredient, and either alone or mixed with other bodies it forms a good Cement (q.v.). Personal ornaments, such as chains and bracelets, are largely made of lac in India, and, when mixed with sulphur and some colouring matter, it is used there for coating wooden toys. Another mixture of lac with vermilion, closely resembling red sealing-wax in appearance, is applied by the Chinese to the surface decoration of boxes, trays, vases, and other small articles.

Lace is an ornamental fabric of linen, cotton, silk, or gold and silver threads, made by looping, knotting, plaiting, or twisting the thread into definite patterns, of contrasted open and close structure. Three distinct varieties of lace are made, two by handwork, known respectively as *needle or point lace* and *pillow-lace*, and one by machinery. To hand-made lace the term real lace is sometimes applied, and, although it may be made in all or any of the varieties of thread above enumerated, in general it is composed of white linen thread of exceedingly great delicacy and tenuity. Machine-made lace on the other hand usually consists of cotton thread of high counts, but it cannot be used of such fineness as linen; while with machines it is quite impossible to rival the combined grace, delicacy, and strength of ornamental structure obtainable by the skill and patience of the hand-worker. Nevertheless machine-made lace is a marvellous triumph of mechanical ingenuity, and more inventive genius has been devoted to its production than has been bestowed on any other branch of textile industry.

Lace on one side, as needle or point lace, is closely allied to embroidery; pillow-lace is derived from and merely an elaboration of plaited fringe-work; and machine-lace is a development of fancy weaving. Although we have these three distinct methods of lace-making, combinations of the whole may be found in one piece of modern lace, and frequently the products are so similar that it requires both experience and close observation to distinguish what is made by the needle from the plaited product of the pillow, or even the twisted lace of the machine. Technically, lace consists of two elements, the pattern, flower, or gimp which forms the closer-worked and more solid portion of the fabric, and the ground or filling which serves to hold the pattern together and in its proper place. In some varieties of lace, however, the ground is almost entirely wanting, and the pattern holds together by joining at the edges where two portions of the design meet and touch. In other cases the ground consists of ties or brides, thin loops or plaits passing from the edge of one portion of the pattern to another contiguous, and thus tying them together. More frequently the ground consists of a delicate filmy honeycomb called a *réseau*, of which the simplest form is the bobbin-net, now made by

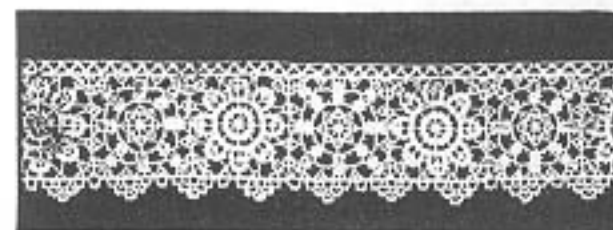


Fig. 2.—Reticella Needle-point Lace, Italian, 16th century.



Fig. 1.—Part of Liturgical Veil or Cover, in *punto a maglia* or *lacci* work.



Fig. 3.—Rose-point, Venetian, 18th century.

machinery. On the réseau the pattern is sometimes stitched down after being separately made, such lace being known as *appliqué* or applied; in other cases pattern and réseau are formed together by needle or bobbin or by both. Other technical terms are met with in the description of lace—as *cordonnet*, a stout thread or several threads together employed to outline the pattern; *picot*, a minute loop worked on the edge of ties or flowers for their enrichment; and *modes*, which are ornamental fillings, variations of the réseau, which is always a plain honeycomb mesh.

Point-lace is a fabric which appears to have been arrived at through the efforts to produce light, graceful, and airy effects in embroidery. It is not known to have been made earlier than the first half of the 16th century; and its original production, as well as its most varied triumphs, are associated with Venice. The stages by which it developed from embroidery-work can be traced from the illustrated pattern-books for embroiderers which were issued early in the 16th century. In these books we find two styles of work intermediate between embroidery and lace-making, one of which consists of patterns cut out of stuff, and having the cut edges sewn over with a button-hole stitch, such work being known to the Venetians as *punto tagliato*. The second method of producing a lace-like effect was by cutting the individual threads in any texture in accordance with a definite pattern, and drawing out the cut portions, the resulting design, partly open work and partly close, being known as *punto tirato*. The converse of this consisted in darning in patterns on a gauze or other open woven texture, a class of work termed by the Italians *punto a maglia* (see fig. 1), and by the French *lacs* or *lassis*—whence our 'lace,' which has taken the place of the earlier name *pasement* or *pasement*. The earliest true needle-lace of Venice, known as *punto in aria* or *reticella*, was in its design similar to the cut work of the pattern-books, showing only rectilinear and geometrical forms, as in fig. 2. A gradual development can be traced from such simple forms into rich floral ornaments and scrolls, till early in the 18th century, in the very delicate needle-point with meshed ground known as *point de Venise à réseau*, we come to the richest and most elaborate products of the north Italian needlewomen. The most characteristic and valuable of the laces of Venice is that known in Britain as *rose-point* (French *gros-point*) (fig. 3), which consists of patterns worked in relief like sculptured work, forming strong and solid flowers and scrolls, held in position by ties or brides enriched with picots.

With such lace the robes of great ecclesiastics and wealthy nobles were adorned, and it was also employed for the ornamentation of altar covers and other church textures. In the making of point-lace the design is first drawn on a piece of parchment, which is then stitched down to a backing of stout linen. Over the lines of the design one or more threads of linen are stitched lightly down, and the slow work of filling up the pattern with button-hole stitches proceeds on the thread outline so obtained. The methods of working are numerous, and some of the stitches indeed have been lost, but commonly the pattern or cloth is obtained by laying down a series of threads parallel to each other, as in fig. 4, and over stitching them as shown. For the brides or réseau a single thread may form the foundation, it also being closely stitched over, as seen in fig. 5. When pattern and fillings are finished, it remains only to cut the stitches which hold the outlining threads to the parchment and the linen backing, thus liberating the lace. From Venice the art of making point-lace travelled out to other Italian towns, and westward to France and Flanders. Principally owing to the efforts of the minister Colbert, who in 1665 chartered a company with exclusive privileges for ten years and a subsidy of 36,000 livres, the art was firmly established in France, ateliers being established in several of the principal towns.

Among these places was Alençon, where Venice lace of very fine quality was being made by a

lady named Laperrière prior to the establishment of Colbert's company. Alençon lace and the closely-allied fabric made at the neighbouring town of Argentan attained great perfection during the 18th century. The designs employed were distinctively French in character, and the réseau and modes which formed the filling showed a minute and filmy delicacy unapproached by the products of any other district (fig. 6). Point-lace also formed

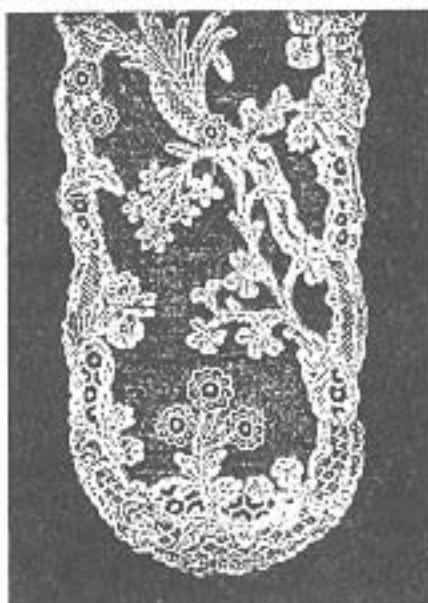


Fig. 6.—Portion of Alençon Lappet; French, late 17th or early 18th century.

one portion of the manufacture carried on at Brussels. The ground of the old Brussels lace is sometimes, though rarely, of needle-point, but the flower, which is made separately and sewed on, or applied to the ground, is, in fine specimens, frequently needle-made. *Pillow-lace.*—It is an undecided question whether pillow-lace originated in Italy or in Flanders. From a picture by Quentin Matsys, painted in 1495, we have evidence that the making of pillow-lace was known in Flanders at that early date; but about the same time it was also being worked in Venice under the name of *Merletti a piombini*. While point-lace making has always been the distinguishing character of Italy and the south, the making of pillow-lace became and remains distinctively associated with the Flemish towns and with England. For the production of pillow-lace the pattern is first drawn in full size on a piece of parchment, which is then fastened to a pillow or cushion made to rest in the lap of the worker, and into which pins may be easily and firmly stuck at any required point. The pattern is then pricked over with pin-holes at every point where pins require to be inserted in the subsequent work of twisting and plaiting. The lace-maker is also provided with a series of small bobbins, round the upper part of which the thread to be used is wound, and even for the production of a half-inch band of lace of simple pattern a vast number of pins and as many as fifty bobbins may be required, while for elaborate patterns twelve hundred bobbins may be brought into requisition on a single pillow. The whole work in pillow-lace is the result of twisting and plaiting, and the pattern is often outlined and sometimes filled up with thread of a stouter character than that used on the mesh and fillings. The simplest ground in the pillow-lace consists of the twisted net or bobbin-net, originally made on the pillow, but now entirely made by machinery (see fig. 7). More commonly the net is partly twisted and partly plaited; and the variations in the mesh so formed are characteristic of the different classes of pillow-lace. Thus, the mesh of Mechlin lace consists of four twisted and two plaited sides, as seen in fig. 8. The mesh of Brussels pillow-lace is similar to that of Mechlin, but the plaited sides are longer (fig. 9), while the Valenciennes mesh is plaited throughout. These differences in the form of the ground of pillow-laces give a different

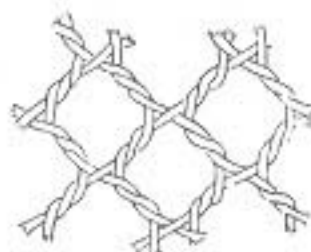


Fig. 7.

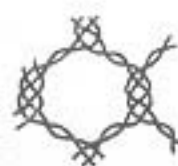


Fig. 8.

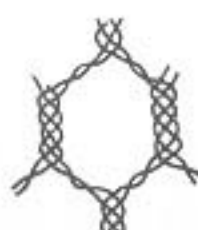


Fig. 9.

appearance to the reticulations. The flower or pattern of the lace is worked so as to give it the appearance of plain woven cloth (see fig. 10). The Valenciennes mesh renders that variety more solid and durable than any of the others. Much of the modern Brussels lace has now a machine-made ground instead of the ancient pillow-meshes, on which the separately-made flowers are applied or sewed by the imperceptible fine joining-stitch. The making of pillow-lace in Honiton and other localities in the south-west of England was begun towards the end of the 16th century by refugees from the Low Countries. In 1662 parliament, desirous of encouraging native lace-making,



Fig. 10.



Fig. 11.
Border of Mechlin Pillow-lace, early 18th century.

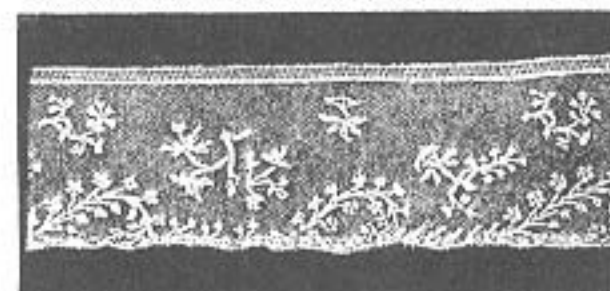


Fig. 12.—Valenciennes Pillow-lace, with réseau ground, late 18th century.

prohibited the importation of all laces of foreign manufacture. Lace-workers were thereupon encouraged to settle in England; but as the fine thread necessary for their work was not forthcoming they were forced to return to their native

land. A vigorous smuggling trade between Brussels and England ensued, and the lace so introduced was freely sold as English point, whence Brussels lace came to be generally known as *Point d'Angleterre*. Honiton lace from the 17th century downwards has continued to be made in the same style as the Flemish laces, but at no time has it attained the celebrity acquired by the products of the great centres of the pillow-lace making in Belgium and the north of France. Fig. 13 is a fine example of Honiton lace-work.



Fig. 13.—Portion of Honiton Lappet, 18th century.

The successful imitation of hand-made lace by machine-work, and the consequent enormous cheapening of material which bears a superficial resemblance to the costly product, has proved almost fatal to the arts of needle and pillow-lace making. Of late years an attempt has been made to re-establish the manufacture of fine point-laces on the island of Burano, near Venice. Similarly, efforts have been made to revive the industry in Honiton, and at the present time much is being done to encourage the development of the art in various directions in conventual and other establishments in Ireland. The stimulus in all these cases is, however, obviously artificial, and it cannot be said that there is at present any really healthy indication of revived demand for these supreme products of patience and ingenuity.

Machine-lace.—The ground and simplest element of pillow-lace being a network of meshes, the earliest

efforts of inventors were directed towards the producing of machinery for fabricating similar netting. The hosiery-frame, which had been invented by William Lee towards the end of the 16th century, was the first apparatus with which it was attempted to make a lace-net, and about 1764 a modification of the frame was devised by which an open loop-net was produced. By the various devices familiar to hand-knitters fancy patterns could be produced on this machine. The loop fabric, however, had the great disadvantage of unravelling freely at any point where it was broken, as it was constructed of a continuous single thread. At a subsequent period what was known as the warp-lace machine was introduced, in the use of which a separate thread is supplied to each hooked needle employed in the production of the web. On these warp-threads loops are formed by mechanical means, and as they can be moved by the machine either to the right or to the left, neighbouring warps and loops are joined together, and in this way a solid web, which can be cut without unravelling, is obtained. Towards the end of the 18th century a great variety of figured lace began to be made on the warp-machine, and in a greatly improved form it still continues in use.

A new era, however, in machine lace-making was inaugurated when, in 1809, John Heathcoat patented his second bobbin-net machine, by which

it was made possible to twist or wrap round each other an indefinite number of threads, and to cause any one thread to traverse, mesh by mesh, every other thread in the width of the fabric being netted. The bobbin-net machine of Heathcoat became the foundation of an enormous industry, and the inventor reaped both honour and ample pecuniary reward for his remarkable ingenuity. His frame has been modified by many inventors, but the most important improvements were effected by John Levers in 1813. The lace-making machine now principally used is known as the Levers machine, but of its complicated structure it would be quite impossible to convey any clear conception within moderate limits. The structure of the simplest fabric produced by it is shown as it appears on the frame in fig. 14; and when dressed and finished this fabric has the appearance indicated in fig. 7, which is common bobbin-net. It will be seen that the texture is formed of a series of vertical parallel threads which may be taken to represent

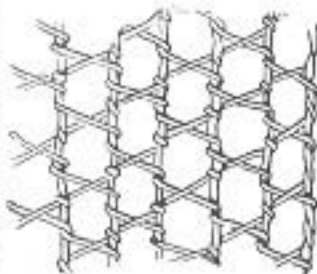


Fig. 14.

the warp of a common web, these being diagonally crossed and interwisted with others which may be looked on as weft-threads. The frame or loom holds the warp-threads vertically, a space being left between each sufficiently wide to admit of a shilling being passed edgewise between them. Behind these threads, and corresponding to the interspaces, is a row of ingeniously constructed flat bobbins or reels resting in an arrangement called a *comb-bar* or *bolt-bar*. These are so placed that with the first movement of the machine each bobbin, which carries its thread with it, passes through two of the parallel and perpendicular threads of the warp, and is lodged in another and similar bolt-bar in front of the warp. But this front bolt-bar, besides an advancing and receding motion, has another movement, called *shogging*—from right to left. When it receives a bobbin by its forward motion it draws back, bringing the bobbin and thread through two of the upright threads; then it *shogs* or moves to one side, and goes forward again, taking the thread through the next two warp-threads, and lodging the bobbin on the back bolt-bar again, one distance beyond its last space; this it recovers by the next movement, and it again passes through the first space, to be again received by the front bolt-bar. By these movements the bobbin-thread is twisted quite round one upright thread of the warp; another movement then shifts the bobbin, so that it will pass through the next pair of upright threads, and so carry on its work, the warp-threads moving at the same time, unwinding from the lower beam, and being rolled on the upper one. There being twice as many bobbins as there are threads in the warp, each bolt-bar having a set which it exchanges with the other, and all being regulated with great nicety, a width of lace

is made in far less time than has been required to write this short description. The additions to and variations upon these operations (which only apply to bobbin-net), for the production of patterns, are numerous and complicated—each pattern requiring new combinations; but they all depend upon the variations which can be given to the movements of the flat disc-like bobbins.

Gold Lace and Silver Lace.—The so-called gold thread which is used in textiles consists of silver-gilt wire, or for commoner purposes copper-gilt wire, either round or flattened into a fine ribbon.

These wires may be so used for weaving and embroidery purposes, but generally what is called gold thread consists of a yellow thread of cotton or linen round which the flattened gold wire is spirally wound so as to completely encase it. Silver wire is similarly prepared and used, being wound on a white instead of a yellow basis. Gold and silver threads may be used in ordinary lace-making, but what is generally termed gold and silver lace consists of braids, ribbons, and bands of these materials employed for embroidery and braiding, and for the ornamentation of uniforms and official robes, badges, &c. The use of gold and silver wire in textiles is of great antiquity, and sumptuous garments enriched with precious metals must have been used in Egypt for royal and priestly personages.

Lacquer. Ornamental or useful articles of brass, such as gas-fittings and some kinds of furniture, are usually lacquered to preserve the surface from discoloration or corrosion. Iron, tinplate, and other metals and alloys are also sometimes lacquered. The lacquer used is composed essentially of shell-lac or seed-lac, or both, dissolved in spirits of wine. But its composition varies considerably. One kind consists of 2 parts of shell-lac dissolved in 20 parts by weight of alcohol, less than 1 part of turpentine being mixed with it. It is customary, however, to add small quantities of one or more gum-resins, such as sandarach, amber, and anime, to the lacquer, which is coloured with gamboge, dragon's blood, and other substances. The brass, which is first heated till the hand can just safely touch it, generally receives two coats of lacquer: but sometimes the first coat is put on when the metal is cold. In the case of dark lacquering the brass is first bronzed and coated with black lead. Coal and tobacco smoke, as well as the vapour or fumes of some chemical substances, injure lacquered surfaces.

Lacquer-ware.—The lacquer used for the celebrated lacquer-ware of Japan differs entirely from the lacquer used for brass. The body of this ware is of wood, and the lacquer or varnish with which it is coated is the juice of the lacquer-tree (*Rhus vernicifera*), sometimes also called the varnish-tree. This remarkable lacquer not only forms a very hard surface, but, unlike other varnishes, it stands a considerable heat without injury, so that in Japan lacquered vessels are used for hot soups and hot alcoholic drinks. There are numerous kinds of Japanese lacquer-ware, the simplest kind being perhaps that with the grain of the wood seen, for which a fine transparent lacquer is used. For black lacquer-ware the juice or varnish is darkened with galls and a salt of iron, and for red it is mixed with about 20 per cent. of cinnabar; orpiment, oxide of iron, and Prussian blue being also used as colours. In the case of gold and silver lacquer-wares the varnish is mixed with about 30 per cent. of the powder of these metals in a fine state of division, so that when the surface is polished it shows a metallic lustre. Tin is used to imitate gold, the yellow hue being given by colour in the varnish.

The lacquered surface of the best ware is prepared by a very tedious process, owing to the number of coatings it receives. For the several preliminary ones crude lacquer is used, together with a single coating of powdered biscuit earthenware and water, the surface being rubbed with a whetstone after each. Two or three more coatings of lacquer are next applied, each being rubbed with charcoal and water. For the finishing coat the best lacquer is employed, and this is polished with calcined deer-horn, finely powdered, the finger and a little oil bringing up the final gloss. The various articles made, such as boxes, vessels, trays, cabinets, &c., are decorated either by inlaying with metal, ivory, or mother-of-pearl, by speckling and gilding with gold or silver, by designs in colour, by relief paintings, or by carving. The art

of lacquering is a very ancient one in Japan, and fine specimens of old work bring very high prices.

Lactic Acid, $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$, the acid contained in sour milk. In the pure state it is a colourless, transparent, syrupy liquid, of specific gravity 1.215. It is without smell, has a sharp acid taste, and is miscible with water, alcohol, and ether. It is formed in milk by the fermentation of the milk-sugar under the influence of an organised ferment. On a large scale it is usually prepared from cane-sugar in the following manner: 7 lb. of cane-sugar and $\frac{1}{2}$ oz. tartaric acid are dissolved in 4 gal. of water and allowed to stand for a few days; then 4 oz. of rotten cheese rubbed up in a gallon of sour milk, and $2\frac{1}{2}$ lb. of zinc oxide (zinc white) are added, and the mixture is thoroughly stirred and kept at a temperature of about 105°F . for eight or ten days. The liquid is boiled to stop the fermentation, filtered, and evaporated till the zinc lactate which it contains crystallises; this is then re-dissolved in water, decomposed with sulphuretted hydrogen, the mixture filtered to free it from zinc sulphide, and evaporated on a water-bath.

Lactic acid occurs very widely distributed as a product of the natural fermentation of sour vegetable materials, such as sauerkraut; it is also found in the stomach and intestines. An isomeric acid of the same composition but slightly different properties, called *sarco-* or *para-lactic acid*, occurs as a product of waste of animal tissues, and is found in muscle of all kinds, especially after violent exertion or artificial tetanus. *Sarco-lactic acid* has been frequently detected in blood soon after its removal from the body, in quantities usually below 1 part per 1000, but it apparently does not occur in normal healthy blood while in the body.

The tests for lactic acid are not very satisfactory. On addition of lead acetate and alcoholic ammonia to a solution containing lactic acid an insoluble lead lactate, $3\text{PbO}, 2\text{C}_2\text{H}_3\text{O}_2$, is precipitated as a white powder. The properties and amount of water of crystallisation of the zinc lactates are also characteristic. Most of the lactates are crystalline and soluble in water.

Lactometer, or GALACTOMETER, a very simple instrument for testing the richness of milk; it consists of a glass tube graduated to 100 parts. New milk is poured in up to the top of the graduated part and allowed to stand; and when the cream has completely separated the value of its quantity is shown by the number of parts in the 100 which it occupies. Another form of instrument was invented by Döffel, consisting of a small hydrometer with a scale 2 inches long divided into 20 degrees, the zero being placed at the point to which the instrument sinks in water, and the 20th degree corresponding with the density 1.0383. This instrument is preferred by the continental chemists; and 14° is held to show milk undiluted with water.

Lampblack is the soot or amorphous carbon obtained by burning bodies rich in that element, such as resin, petroleum, and tar, or some of the cheap oily products obtained from it. The supply of air is limited or controlled so as to produce a smoky flame, and the smoke passes into a chamber with some arrangement for receiving the abundant deposit of soot. For some of the finer qualities of lampblack this soot or carbon is purified by heating it in closed vessels. A large quantity of lampblack has been made in the United States by the imperfect combustion of natural gas. Lampblack is a useful pigment for artists both in oil and water colour, a coarser kind being employed by house-painters. It is the chief ingredient in Indian Ink (q.v.), and along with boiled linseed-oil forms printing-ink. Of it is formed the pigment for the carbon paper used in the Autotype Process (q.v.). Lampblack is also employed in the preparation of some kinds of leather, and for other purposes.

Larynx (Gr. *larynx*) is the organ of voice, and plays an important part in the respiratory process, as all air passing either to or from the lungs must pass through it. It is a complex piece of mechanism, resembling a box composed of pieces of cartilage which are capable of executing movements, and enclosing the vocal cords by which phonation is produced. The larynx is situated between the trachea, or windpipe, and the base of the tongue, at the upper and front part of the neck, where it

forms a considerable projection (especially in men); it opens superiorly into the *pharynx*, or throat, and inferiorly into the windpipe. The principal cartilages of which the skeleton of the larynx is composed are five in number—viz. the thyroid and cricoid cartilages, the epiglottis, and the two arytenoid cartilages.

The *thyroid* (Gr., 'shield-like') consists of two square plates of cartilage united in front at an acute angle, which forms the projection commonly known as the *pomum Adami*, or Adam's apple. Each of these plates is prolonged at the upper and lower posterior corners. The thyroid cartilage forms almost the whole of the anterior and lateral walls of the larynx. The *cricoid* (Gr., 'ring-like')

cartilage is a ring the lower margin of which is parallel to the first ring of the trachea, and to the last-named it is united by fibrous membrane. Its upper border is connected in front with the lower border of the thyroid cartilage by a thick yellow fibrous tissue. It presents two articular surfaces on either side—viz. a lower, which articulates with the inferior cornu of the thyroid cartilage, and an upper, which is oval in form, and supports an arytenoid cartilage. The *arytenoid* (Gr., 'ladle-like') cartilages are pyramidal bodies resting on the oval articular surfaces at the upper and posterior part of the cricoid cartilage.

When *in situ* they present a concave posterior surface. From their connection with the vocal cords, and from their great mobility as compared with the two larger cartilages, the arytenoids play a very important part in the mechanism of the larynx. The *epiglottis* is a very flexible cartilaginous valve (fig. 1, *f*), situated at the base of the tongue, and covering the opening of the larynx. Its direction is vertical, except during deglutition, when it becomes horizontal. It is attached inferiorly by a kind of pedicle to the angle of the thyroid cartilage. Upon removing the investing mucous membrane the cartilage is found to be perforated by numerous foramina. Each perforation admits some fasciculi, of yellow, elastic, ligamentous tissue, which expands on its anterior aspect, and secures the return of the epiglottis to its vertical position, independently of any muscular action. Such is the skeleton of the larynx, hanging as it does from the hyoid bone, with which it is connected by the thyro-hyoid ligament and certain muscles.

The various cartilages which have been described are connected with one another by ligaments, the chief of which are those known as the true and false vocal cords. In their quiescent state the former do not lie parallel to each other, but converge from behind forwards. The length of the vocal cords is greater in the adult male than in the adult female, in the ratio of three to two. In infancy they are very short, and increase regularly from that period to the age of puberty. The mucous membrane of the larynx is part of the extensive respiratory tract, and is remarkable for its extreme sensibility. The length of the chink or aperture of the glottis, which is directed horizontally from before backwards, varies, like the vocal cords, until the period of puberty, when its length, in the male, undergoes a sudden development, while in the female it remains stationary. In the adult male it is about eleven lines in length.

The larynx is provided with two sets of muscles: the *extrinsic*, by which the whole organ is elevated or depressed, and the *intrinsic*, which regulate the



Fig. 1.

Cartilages of larynx and epiglottis, and upper rings of trachea, seen from behind: *a*, arytenoid cartilages; *b*, superior cornu of thyroid cartilage; *c*, its inferior cornu; *d*, posterior surface of cricoid; *f*, epiglottis, with its perforations; *i*, upper margin of thyroid; *t*, trachea.

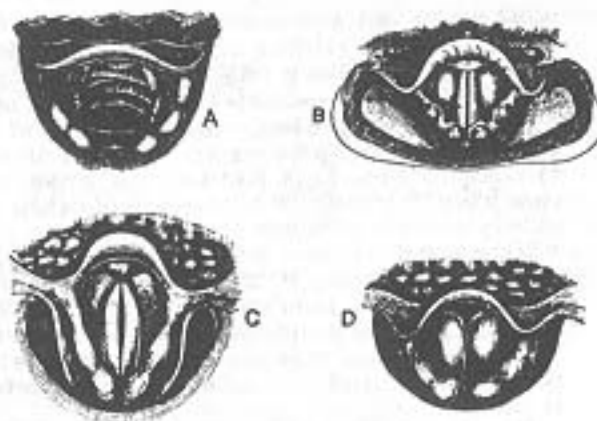


Fig. 2.

A, larynx and trachea on deep inspiration; B, on phonation; C, during falsetto note; D, approximation of the ventricular bands or false cords as it occurs in straining.

movements of the various segments of the organ in relation to one another. By the action of these latter muscles, aided, in some cases, by the extrinsic muscles, the tension of the vocal cords may be increased or diminished, and the size of the opening of the glottis regulated at will (see VOICE). The nerves of the larynx are derived from the superior and inferior laryngeal branches of the pneumogastric or vagus nerve.

That the larynx is the organ of voice is easily proved. Thus, alteration in the mucous membrane covering the vocal chords causes hoarseness or other change of voice; ulceration of the vocal cords destroys or injures the voice; opening the trachea below the vocal cords, or section of the inferior laryngeal nerves, destroys the voice; and sounds like those of the voice may be produced by experiments on the dead larynx.

DISEASES OF THE LARYNX.—*Laryngitis*, or inflammation of the larynx, may be either an acute or a chronic affection. Acute laryngitis, in its more

severe form, which is fortunately rare, commences with a chill, which is followed by fever, with a full strong pulse, a hot skin, and a flushed face. There is also soreness of the throat, hoarseness of the voice, great difficulty in swallowing, and a feeling of extreme constriction of the larynx. There is a painful stridulous cough, but only a little mucus is ejected. Great difficulty in breathing occurs in severe cases, the act of inspiration being prolonged, and wheezing results, in consequence of the swollen membrane of the glottis impeding the entrance of air. On examining the larynx, the epiglottis is observed to be of a bright red colour, erect, and may be so much swollen as not to be able to descend, and may close the glottis during deglutition; the other parts of the larynx are seen to be more or less swollen according to the severity of the case. The patient may exhibit symptoms of great anxiety and distress; his lips may become blue, his face of a livid paleness, his pulse irregular and very feeble, and at length he may sink into a drowsy state, often preceded by delirium, and quickly followed by death. The disease is very rapid, ending, when fatal, in three or four days, and occasionally in less than one day. Although we have here described what may occur in exceptionally severe cases, acute laryngitis rarely passes beyond hoarseness, a feeling of constriction, slight feverishness associated with cough and marked hoarseness.

Laryngitis is most commonly due to exposure to cold; but the inflammation rarely reaches a dangerous height in these cases. The dangerous forms are usually the result of injury (e.g. swallowing boiling or corrosive substances); or they may be a secondary result of ulceration, or due to infection, such as erysipelas. In simple cases confinement to a warm room, with soothing steam inhalations, will, if the voice be rested, usually effect a cure. In severe cases sucking ice, leeching, scarification of the swollen parts, and even tracheotomy may be necessary. In persons who use the voice much the affection is apt to become chronic, or indeed to be chronic from the beginning without the super-vention of an acute attack. Laryngotomy is discussed at TRACHEOTOMY.

Ulceration may occur in phthisis, syphilis, lupus, and after typhoid fever. Cancer of the larynx may lead to ulceration, but the primary disease constitutes a tumour. Innocent growths are also met with, the more common varieties being papillomatous (warts) and fibromata. Paralysis of the laryngeal muscles may involve those

muscles only which close the glottis, in which case the affection is often due to hysteria and easily cured. Paralysis of the muscles which open the glottis or affecting all the muscles is usually due to some grave disease of the nervous system, chest, or throat, and is often incurable. The treatment must depend upon the condition discovered by laryngoscopic examination in each case.

THE LARYNGOSCOPE.—Although successful attempts had been previously made by Garcia to explore the recesses of the larynx by means of a reflecting mirror, it was not until two German physiologists, Türk and Czermak, took up the subject, in 1857 and 1858, that the great importance of laryngoscopy was first generally recognised. The laryngoscope is a small mirror placed on a stalk attached to its margin, at an angle of from 120° to 150°, the stalk being about six inches in length. The mouthpiece of a large reflector, with a central opening through which the observer looks, is held between the molar teeth; or, what is better, the reflector may be attached to a spectacle frame or forehead band by a stiffly working ball-and-socket joint. The rays of the sun or of a good lamp are concentrated by means of this reflector on the laryngeal mirror, which is placed against the soft palate and uvula. The laryngeal mirror, previously warmed, and introduced with the right hand, which rests by two fingers on the jaw, is maintained at such an inclination that it throws the light downwards and illuminates the parts to be examined, while at the same time it reflects the images of these parts into the eye of the observer through the central opening of the reflector. By this means we can look through the larynx into the trachea or windpipe, and can see the actual position of small tumours, ulcers, &c., whose existence would otherwise have been at most only suspected; and the precision and accuracy of diagnosis to which we can thus attain enable us to employ rational means of local treatment to an extent that was quite impossible before the introduction of laryngoscopy. It is also possible to illuminate the larynx by throwing a powerful and concentrated light upon the front of the throat, and introducing a mirror into the dark mouth (*Durchleuchtung* of German physicians).

Laudanum, or more correctly **TINCTURE OF OPIUM**, is the most generally used of all the preparations of opium. It is obtained by macerating the sliced or powdered drug in dilute spirit, and filtering.

It is of a deep brownish-red colour, and possesses the peculiar odour and smell of opium. One of the greatest objections to it is that it is liable to great variations of strength. When the tincture of opium is ordered a definite strength is always obtained, but under the name of *laudanum* various compounds are sold, and the former term should therefore alone be used. Laudanum is a powerful anodyne and soporific, but is more liable to cause headache than the solution of one of the salts of morphia. Its general action and its uses will be described in the article OPIUM. The dose for an adult varies from ten minims to a drachm. To children (as is the case with all opiates) it must be given with extreme caution. One minim, or about two drops, has been known to prove fatal to an infant. See POISON.

Lavender (*Lavandula*), a genus of plants of the natural order Labiate, having the stamens and style included within the tube of the corolla, the corolla two-lipped, the upper lip bifid, the lower trifid. The Common Lavender, or Narrow-leaved Lavender (*L. vera* or *L. angustifolia*), grows wild on stony mountains and hills in the south of Europe, and in more northern regions is very generally cultivated in gardens. It has a delightful aromatic fragrance, and an aromatic bitter taste, and contains a great quantity of a volatile oil, *oil of lavender*. The whole plant possesses stimulant properties, and is used in medicine, but particularly the spikes of the flowers, as a tonic, stomachic, nervous stimulant, &c. Lavender-flowers are often put into wardrobes to keep away moths, and are much used in perfumery. *Oil of Lavender* is procured by distillation of lavender-flowers with water, and is rather lighter than water, pale yellow, very fluid, and very fragrant; it requires 70 lb. of flowers to yield 1 lb. of oil. *Spirit of Lavender* is made by distilling lavender-flowers with rectified spirit; *Lavender Water*, one of the most popular of all perfumes, by dissolving oil of lavender with smaller quantities of other

volatile oils in rectified spirit. Lavender is extensively cultivated for its flowers at and near Mitcham in Surrey, and at Hitchin (q.v.) in Hertfordshire. Broad-leaved Lavender (*L. latifolia* or *L. spica*) is also a native of the south of Europe, but is more tender than common lavender. It is also less fragrant, and the oil which it yields is called *Oil of Spike*, and sometimes *Foreign Oil of Lavender*. This oil is used by painters on porcelain, and in the preparation of varnishes.

Laying, or LAYERING, a mode of propagating trees, shrubs, and perennial herbaceous plants which is very frequently employed by gardeners and nurserymen. It consists in bending and fastening a branch, so that a portion of it is imbedded in earth, there to throw out roots, the extremity being made to grow erect in order to form a new plant. The separation from the parent plant is not effected till the layer is sufficiently provided with roots. Any injury which prevents the free return of the sap greatly promotes the formation of roots, and a notch is therefore usually made in the under side of the branch, at the place where the formation of roots is desired; it is also often a little split up from the notch; and sometimes a ring of bark is cut off, or a wire is twisted round it. The time which must elapse before the layer should be separated from the parent plant is very various; a few weeks being sufficient for some, and two years requisite for others. Many plants which cannot readily be propagated by cuttings are more easily and successfully propagated by layers.

Lead is one of the metals which have been known from early times. It is mentioned in Job, xix. 24, and articles made of it by the ancient Romans—some of them inscribed and dated—such as water-pipes, water-tanks, weights, rings, and small ornamental cylinders, are still preserved. As examples found in the grounds of some of the old abbeys and cathedrals show, the Roman method of making pipes from sheet-lead, which differs from the modern way, continued in use till late in the middle ages. Small lead weights of curious forms have been found among Viking remains dating as early as the 10th century. Of lead compounds, litharge and red lead were known to the ancients.

Lead (symbol Pb, atomic weight 207) is a soft metal of a bluish-white colour, tending to gray, and having also a bright metallic lustre when newly cut or melted. Its surface soon tarnishes, however, when exposed to the air, by taking on a thin film of what is supposed to be suboxide. But the oxidation increases so slowly that lead suffers less than most ordinary metals either by exposure to atmospheric agencies or by being placed in damp soils. Lead can be scratched with the nail, and easily cut with a knife, and it makes a streak upon paper. Its specific gravity varies from 11.352 in the ingot to 11.365 when rolled into sheets, and its melting-point is 633° F. (334° C.). It is highly malleable and in a less degree ductile, but its tenacity is small—a wire $\frac{1}{4}$ th of an inch being unable to carry a load of 20 lb. Lead is not a good conductor of heat or electricity. When gently heated it can be forced by pressure through perforations, so that pipes and solid rods for rifle-bullets, &c. are in this way manufactured. It is well to bear in mind that pipes, gutters, and cisterns made of lead are injured by hot water. The two former are often twisted and rendered useless by the constant flow of hot liquids through them. Neither sulphuric nor hydrochloric acid in the dilute state has any action upon lead.

The Action of Lead upon Water is of great importance, because the metal is so much employed for pipes and cisterns, and because lead salts dissolved even in minute quantities in drinking-water act as cumulative poisons, and are therefore injurious when taken for some length of time into the system. Lead is rapidly acted upon by pure water to which air has access, such as rain; and it is also dissolved to an appreciable extent by the water of rivers or lakes which is practically free from lime. In these cases the water after passing through lead pipes has an alkaline reaction. The combined action of air (i.e. of its free oxygen) and water oxidises the lead. After a time this hydrated oxide which dissolves is converted by atmospheric carbonic acid into an insoluble basic carbonate of lead. The oxide is again formed and the corrosive action continues or may continue. Bicarbonate or sulphate of lime, which are common salts in potable waters, prevent water acting on lead. So do some

other salts; but ammonium nitrate, on the other hand, assists the solution of the lead. Sir Robert Christison found that a very small amount of peat-extract in solution prevents the action of an otherwise pure water upon lead. But in the case of even a soft and almost pure water, like that supplied to Glasgow from Loch Katrine, the action is so slow that short-service pipes of lead when constantly used are harmless.

Native lead is of rare occurrence, but it has been found very sparingly in a few places. The metal is obtained chiefly from galena or sulphide of lead, which forms veins in different geological formations. There are several oxides of lead, two of which, plumbic oxide and red oxide, are of importance in the arts.

Plumbic Oxide (monoxide of lead, massicot, litharge), PbO . Massicot, from which red lead is manufactured, is obtained in the form of a yellow powder by heating lead to dull redness. Litharge is produced when lead is oxidised, as in the cupellation furnace, at a high temperature in a current of air. The melted litharge flows from the cupel into iron pots, and after cooling breaks up into crystalline scales of a colour varying from a pale to a reddish yellow. This is called flake litharge, and when ground it is termed buff or levigated litharge. Both massicot and litharge enter into the composition of Cements (q.v.). Litharge is used in the fabrication of oil-varnishes to increase their power of drying, in the preparation of lead plaster, and for glazing earthenware. **Red Oxide of Lead** (red lead or minium), Pb_2O_3 , is occasionally found native. Its manufacture is referred to below. There is another kind of red lead, called orange lead, containing more oxygen than minium. **Plumbic Peroxide** (binoxide of lead, puceoxide), PbO_2 , is obtained by treating the red oxide with dilute nitric acid. This oxide, which is of a brown colour, is used mixed with sulphur along with other ingredients for tipping some kinds of matches, the mixture of puceoxide with sulphur being spontaneously inflammable when rubbed.

The most important lead salts are the following: **Plumbic Carbonate** (carbonate of lead, white lead), $PbCO_3$; the cerussite of mineralogists, and now largely mined in the United States as an ore of lead. White lead is manufactured on a large scale by the process described below. **Plumbic Chloride** (chloride of lead), $PbCl_2$. The minerals matlockite and mendipite are both oxychlorides of lead. By a process introduced by H. L. Pattinson, a basic chloride of lead is made for use as a white pigment, which is, however, not so serviceable as ordinary white lead. **Lead Acetate** (sugar of lead), $Pb(C_2H_3O_2)_2 \cdot 3H_2O$, is prepared by dissolving massicot in dilute acetic acid. It can be obtained in transparent crystals or in scales by evaporating the solution. It is soluble in $\frac{1}{4}$ part of cold water, and in eight parts of alcohol. Like litharge, it is used in the manufacture of oil-varnishes, and it is an important substance in medicine. For the chromate of lead, which is employed as a yellow pigment, see under CHROMIUM.

The following are some of the tests for lead compounds in solution: An addition of hydrochloric acid produces, unless in very dilute solutions, a white precipitate of lead chloride unaltered on adding ammonia. Sulphuretted hydrogen produces a black precipitate, and this precipitate when heated with strong nitric acid is converted into insoluble white sulphate of lead. Chromate of potash produces a yellow precipitate, which has the same appearance as the precipitate this chromate gives with baryta, but the chromate of lead is soluble in caustic potash, while chromate of baryta is insoluble. Lead compounds, when mixed with a little carbonate of soda, are easily reduced to the metallic state if heated on charcoal in the inner blowpipe flame.

Ores and Smelting.—Until recent years only a small quantity of lead was obtained from any other ore than Galena (q.v.). This is a sulphide of lead (lead, 86.6; sulphur, 13.4), and is found extensively, more or less pure or associated with other ores, in Great Britain, Germany, Spain, and other European countries.

Some of the rarer lead minerals, not already mentioned, are anglesite or sulphate of lead, lanarkite, which is a basic sulphate, pyromorphite or phosphato-chloride of lead, and bournonite, consisting of the sulphides of lead, copper, and antimony. All galena is more or less argentiferous.

Galena when taken from the mine is broken up

into small pieces or reduced to powder, and the impurities, in so far as these can be removed mechanically, separated by machines noticed under METALLURGY. If the dressed galena is nearly pure, as it often is, the smelting operation is simple. A charge of ore amounting to at least 20 cwt. is first partially roasted or calcined for about two hours on the bed of a reverberatory furnace, such as is shown in fig. 1, which results in one portion

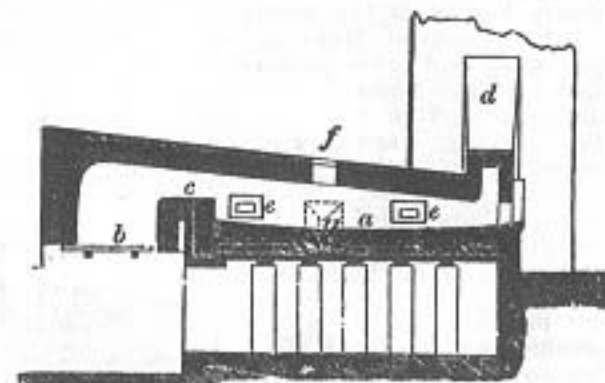
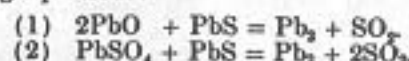


Fig. 1.—Section of a Reverberatory Lead-furnace: a, hearth on which ore is spread; b, the fireplace or grate; c, the fire bridge; d, chimney; e, e, working doors; f, opening for supplying ore; g, tap-hole.

being converted into oxide and another into sulphate of lead, while some of the sulphur goes to form sulphurous acid, which escapes as gas. There remain on the hearth of the furnace oxide, sulphate, and some unaltered sulphide of lead. These, when the heat is raised and the furnace doors closed to practically stop the supply of air, react upon each other, forming sulphurous acid and metallic lead. Towards the end of the process some lime is thrown in to aid in the manipulation of the slag and undecomposed ore; and when a further portion of metal is extracted from these the melted lead is run off into a vessel, and the slag removed from the furnace. The changes which take place in the later or melting stage of the process are shown by the following equations:



In the northern lead districts of Great Britain the calcined ore is removed from the reverberatory furnace and smelted with the aid of a blast of air on a separate ore-hearth called the 'Scotch furnace.'

Owing to lead being to some extent volatile at a red heat, a considerable quantity of the metal would, if not prevented, pass from the smelting-furnaces into the atmosphere as smoke or fume, and cause a loss of, sometimes, 10 per cent. of what the ore should yield. Moreover, lead smoke destroys vegetation for some distance around the furnaces, and herbage on which the fume condenses is apt to poison animals feeding upon it. At Holywell in Flintshire, Alston Moor in Cumberland, and at other lead-works this smoke is conveyed through a system of flues whose combined length amounts in some cases to several miles. Sometimes it is one very long flue. The fume condenses on the sides of these flues, openings being left to collect it. Condensing chambers are also used, in one form of which the lead fume is precipitated by being forced through water. These condensers are constructed to save the expense of long flues, but sometimes both are employed. The lead is of course extracted from the collected fume. In the Harz Mountains, and in some other lead-mining and smelting districts lead is extracted from complex ores—that is to say, from argentiferous galena associated with comparatively small quantities of the sulphides of copper, iron, zinc, and antimony, together with a gangue of quartz (silica), alumina, calcspar, heavy spar, and brown-spar. For such ores what is called the *precipitation by iron* or the *iron-reduction process* is, in some cases at least, more suitable than the air-reduction process described above. A certain proportion of iron is added to the charge of ore in a blast-furnace, with charcoal or coke for fuel, because the sulphide of lead is completely reduced when heated with metallic iron, since this metal has a greater affinity for sulphur than lead. The reduction of these complex ores is, however, rather a combination of processes than a single one. Besides lead and silver, copper and sometimes other metals are obtained as accessory products.

As an example of a water-jacketed blast-furnace for lead-smelting we give in fig. 2 a vertical section

of the cupola-shaped one called the Pilz furnace now in use at Freiberg, and which has also been adopted in the United States. It has eight tuyères, and varies in size from 4 feet in internal diameter, and 14 feet high from the hearth-plates, up to 20 feet in height, with a proportional width across. In the United States, however, the Rachette or rectangular form of blast-furnace seems to be preferred, because its capacity can be increased by lengthening it on plan without also increasing the height, as must be done if a circular furnace is

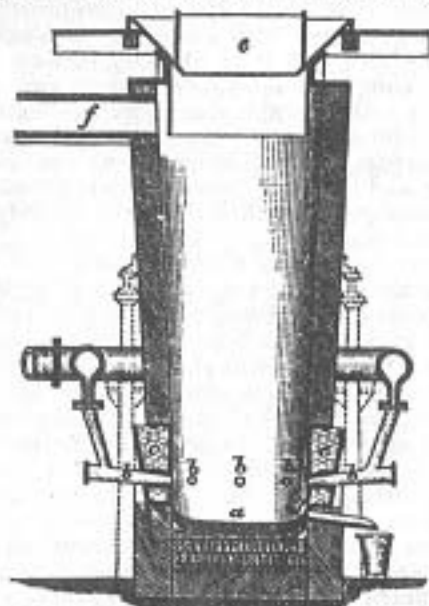


Fig. 2.—Vertical Section of the Pilz Blast-furnace for melting Lead:

a, hearth; b, tuyères, by which air-blast enters; c, water-jacket; d, tap-hole; e, cover; f, flue.

made larger in diameter. The pressure of the blast in these furnaces is from $\frac{1}{2}$ to 1 lb. per square inch. The ore smelted at Leadville, Colorado, is, as already stated, largely cerussite or carbonate of lead, and this is easily reduced in a blast-furnace by coke or charcoal.

Desilverising, &c.—Lead usually contains antimony, tin, zinc, and other metals as impurities. These are separated by fusing the metal in shallow pans, when the foreign metals form oxides, and as such are skimmed off. Lead reduced from galena always contains a little silver, of which 8 or 10 oz. to the ton of lead is a very common proportion, although it often exists in much larger quantity, and as little as 2 oz. to the ton can now

a good deal further. The silver is then obtained from this rich lead by melting it on a flat bone ash cupel, placed in a reverberatory furnace, and exposing it to a current of air which reduces the lead to the oxide, or *litharge* of commerce, leaving the silver on the cupel. Fully 320,000 oz. of silver are in this way annually separated from British lead, the latter at the same time being improved in quality.

The Rozan process for desilverising lead is the same in principle as Pattinson's, except that steam is used instead of manual labour, the result being that there is a considerable saving in the cost.

Another method of desilverising lead, known as Parkes' process, was patented in 1850. By this method the silver is separated by adding to the melted lead from 1 to 2 per cent. of zinc, which has a greater affinity for silver than lead. The zinc carrying the silver with it forms, on cooling, crusts on the surface. From these crusts the zinc is afterwards distilled, leaving silver mixed with some lead as a residue. A modification of Parkes' method was patented in France by Conduric in 1866. He uses superheated steam for the separation of the zinc from the crust or scum, and for getting rid of any foreign metals remaining in the desilverised lead. It is said that a very pure commercial lead is obtained by Conduric's process.

Rolled out into sheets, lead is largely used for roofing houses and for water-cisterns; and water-pipes are now made from it without soldering, as already stated. It is also of great service in the construction of large chambers for the manufacture of sulphuric acid. Its value for the manufacture of shot is well known. Alloyed with antimony, &c., it is largely consumed for type-metal, and with tin for solder. Much lead is also required for the manufacture of pewter, Britannia metal, &c. See ALLOY.

White Lead or Carbonate of Lead is a substance very extensively used as a white pigment, as a cement, and for pottery glazes. White lead is still largely made by the old Dutch process. Metallic lead is cast into the form of stars, gratings, or thin perforated slabs in such a way as to facilitate its conversion into the carbonate. These pieces of lead placed in earthenware vessels, like flower-pots, containing a little weak acetic acid, are built up in tiers in the form of a stack, and surrounded with spent tan or horse-dung. The heat given out from the dung volatilises the acid, which along with the air changes the surface of the lead into the basic acetate, and this is, in turn, converted into the carbonate by the carbonic acid given off from the hotbed. Metallic lead requires from four to eight weeks for conversion into white lead, during which a repetition of these reactions goes on. In 1890 a company was formed in London to work R. MacIvor's process, which consists in acting upon oxide of lead (litharge) by a solution of acetate of ammonia, and then precipitating carbonate of lead from the solution by injecting carbonic acid. By this process white lead is very quickly made. The acetate of ammonia is recovered and used again.

Minium, Red Lead, or Red Oxide of Lead, is much consumed in the manufacture of flint-glass, as a cement, and as a pigment. For glass-making it requires to be made of very pure lead, as a slight trace of copper would impart a colour to the glass. Minium is prepared by heating *massicot* or monoxide of lead to a temperature of 600° F. in iron trays, in an oven, carefully avoiding fusion. More oxygen is thus gradually absorbed; and a bright-red compound is formed which is the red lead of commerce. Orange lead, made from white lead instead of from *massicot*, is a very pure kind of red lead.

Yellow Lead.—This name is sometimes given by manufacturers to a mixture of the oxides of lead and antimony, which is to some extent used to give a yellow colour to earthenware and as a pigment.—The so-called *Black Lead* (q.v.), of which pencils, &c. are made, contains no lead.

LEAD-POISONING, or PLUMBISM.—Minute doses of lead introduced into the system for some time bring on peculiar and distinctive symptoms. In the 18th century, before its cause was ascertained, the disease was well known in Poitou (hence called '*colica pictorum*'), in Devonshire, and in the West Indies. It was proved by Sir George Baker in 1767 that it was due in each case to the presence of lead in the prevalent alcoholic drink of these regions—wine, cider, rum respectively, owing to its introduction during the process of manufacture. It is occasionally met with in consequence of the action

of water, generally very soft water, on the lead pipes through which it passes to the consumers. But it most often attacks persons whose occupation brings them much into contact with lead compounds, particularly those engaged in the manufacture of white lead, painters, and plumbers. The two parts of the body chiefly affected by the disease are the intestinal canal and the nervous system; gout also occurs in association with it.

(1) Lead or painter's colic is much the most common form of the disease. It consists in more or less severe attacks of pain in the abdomen (see COLIC), not differing much except in their persistence and frequent recurrence from pains otherwise produced, attended by obstinate constipation and frequently by vomiting. They may be so slight for some time that they do not interfere with the sufferer's continuing his work. Lead-colic is rarely fatal; but may be so if the cause of the affection is not recognised.

(2) The commonest affection of the nervous system is paralysis of some of the voluntary muscles; usually those first and most affected are the extensor and supinator muscles of the forearm, and the muscles of the ball of the thumb; and from the characteristic deformity thus arising the condition is termed *wrist-drop*. Other muscles may be first or alone affected; but in almost all cases the muscles of the upper limbs are those where the disease manifests itself. It is not certain whether the nerve-trunks or the centres in the spinal cord are the primary seat of morbid change. Atrophy of the brain-substance, or of the optic nerves, epileptic attacks, and coma occasionally occur as results of lead-poisoning. All the nervous disorders are generally preceded by lead-colic.

(3) The association of gout with lead-poisoning is frequent; and the former is certainly sometimes produced by the latter. But it is probable that gouty subjects are specially sensitive to the action of lead. Cirrhosis of the kidneys (see KIDNEYS, DISEASES OF) occurs in some cases; but whether it is ever a primary effect of lead-poisoning, and not due to induced gout, is not quite certain.

Besides the more obvious effects of the poison above described, there are others of great importance, as they aid in the discovery of the cause of the disease. The most distinctive is the formation of a dark line along the edges of the gums close to the teeth, due to precipitation of lead in the form of sulphide in the tissues. The general health usually suffers, the complexion is sallow and the skin dry and harsh.

Prevention.—The most important point to be attended to is that those exposed to the cause of the disease should pay scrupulous attention to cleanliness; should never eat in their workrooms, or without washing their hands; and where dust containing lead is present should wear respirators during their work. Lemonade or some other drink slightly acidulated with sulphuric acid should be used as a beverage, for it forms the insoluble and inert sulphate of lead with any other lead compound which has obtained access to the stomach. Where the water-supply is at fault lead pipes must be discarded, or means must be taken to render the water hard before it is admitted to the pipes.

Treatment.—When lead is present in the system and causing any of the symptoms above described, its removal can be effected by the administration of iodide of potassium (see IODINE). Sulphuretted baths, formerly recommended, are of doubtful efficacy. Lead-colic requires the free administration of castor-oil or other purgatives; and lead-paralysis is often benefited by stimulation of the affected muscles by electricity.

Leather consists of the skins of animals chemically modified by tanning and otherwise, so as to arrest that proneness to decomposition which characterises unprepared skins, and to give to the substance greatly increased strength, toughness, and pliancy, with insolubility and inalterability in water. Some method of preparing skins so as to make them wearable must have been known from the very earliest times, and there yet exist remains of tanned leather made in Egypt not less than 900 years B.C. In modern times the methods and principles of leather-making have come to be well understood; but the processes employed in the

manufacture have not been seriously modified; the attempts made to hasten the essentially slow processes having met with but limited success. There are three methods by which leather is prepared: first, and by far the most important, with tan

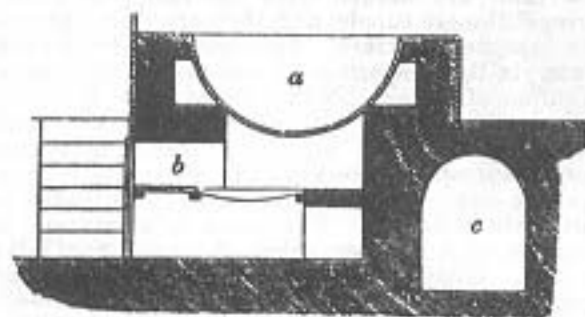


Fig. 3.—Desilverising Pot:

a, pot; b, fireplace; c, main flue.

be profitably extracted. The desilverising process patented by H. L. Pattinson of Newcastle-on-Tyne in 1833 is still much used. A series of cast-iron pots about 6 feet in diameter (see fig. 3) is used in the process. The argentiferous lead from the smelting-furnace is melted in one of these and allowed to cool slowly, and at the same time it is briskly stirred. A portion of the lead is thus made to separate in small crystals, which, as pure lead solidifies at a higher temperature than when it is alloyed with silver, leaves the fluid portion richer in silver. Suppose that the lead to begin with contains 10 oz. of silver to the ton; then if two-thirds of the charge of this pot, which is usually the centre one of several, is transferred as crystals to another pot it will contain only about 5 oz. of silver to the ton. The one-third remaining in the liquid state will contain 20 oz. of silver to the ton. With both portions this process is repeated several times, the one becoming poorer, and the other richer in silver after each crystallisation. When the lead is enriched to the extent of from 250 to 300 oz. of silver to the ton the concentration is usually stopped, although it is sometimes carried

barks and other vegetable substances containing tannin; second, by tawing with alum, bichromate of potash, and other mineral salts; and third, by shamoying or impregnating the raw skin with oil.

The skins of all animals used for leather-making consist chiefly of a fibrous gelatinous substance called collagen, which on being boiled forms the ordinary gelatin of commerce, with an interfibrinous compound called coriin, insoluble in water, but which in common with collagen unites with tannin to form the insoluble and unalterable compound tanno-gelatin, the chemical basis of tanned leather. The compounds are similarly acted on by bichromate of potash and other mineral salts in tawing, whereby insoluble combinations are formed.

The skins of all animals may be made into leather; but in practice the raw materials of the manufacturer consist of the skins of certain animals which are reared and slaughtered primarily for other purposes, and of which the supply is sufficiently large to form the basis of a great industry. Large skins, it may be remarked, such as those of oxen and horses, are in trade termed hides; those of calves, sheep, goats, and other smaller creatures are called skins. Of all leather-making hides the most important are those of oxen, which are primarily distinguished as ox, cow, and bull hides, and calf-skins. To the tanner they come in several forms and from many quarters. The first source of supply is the local slaughter-house, from which the newly-flayed skins called market hides are obtained. From abroad ox-hides come either as wet or dry salted hides, or as simply dried hides, the great sources of supply being Australia, the Cape of Good Hope, the River Plate and South America generally, and China and Japan. From the East Indies there come vast quantities of small hides termed kips, both salted and tanned. Buffalo-hides are

imported in large quantities from Singapore, Batavia, Bombay, Kurrachee, and Calcutta. Horse-hides are brought in considerable quantities from South America, and the knacker's yards at home supply fresh hides, which, however, are generally in bad condition. Sheep-skins, from the vast quantities yearly available in nearly all parts of the world, are a most important source of leather. Besides native supplies the British market chiefly obtains them from Australia and New Zealand, the Cape, and Buenos Ayres. Goat-skins and kid-skins come from the Cape, the East Indies, Asia Minor, and Switzerland; but many of the East Indian and Asiatic skins are when imported already tanned, and require only dressing. A now important source of leather is from seal-skins, the supply of which is derived from the Greenland and Newfoundland fisheries. Other skins which have only a local or a limited market are the walrus, rhinoceros, and elephant, from which leather of great thickness, suitable for polishing-wheels and other mechanical purposes is obtained; and hog or pig skin is an important source of leather for saddle-making and other purposes. The skins of various species of deer and antelope, porpoise and kangaroo, are also sources of leather; and from the Cape there are occasionally sent to the London market skins of the gnu and quagga. As sources of leather for fancy articles there may be mentioned the alligator (a leather now extensively imitated), and certain snakes' and sharks' skins.

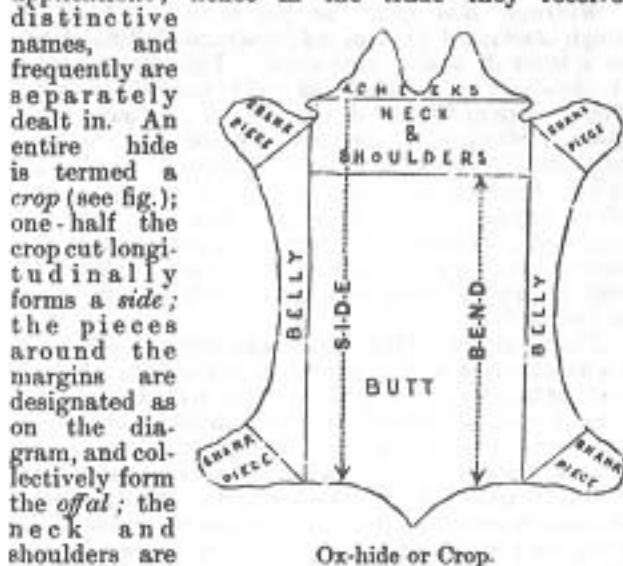
Tanning.—The operations of tanning and the duration of the process vary very widely according to the nature of the tanning materials employed, the nature and thickness of the hides and skins under treatment, and the class of leather being produced. The sources of Tannin (q.v.; and see BARK) are exceedingly numerous, but oak-bark is the most important, and that which produces the most valuable and substantial of all leathers. Oak tannage is, however, a very tedious process, and the common practice is now to hasten the completion of the operation by mixed tannage, in which more rapidly acting agents play a part. In America hemlock-bark from *Abies canadensis* is the most important tanning material; and the mimosa or wattle barks of Australia are very largely used in the colonies as well as in Britain. Standard extracts containing a fixed percentage of tannin have also come into favour for rapid tannage. But, with all the devices which have been suggested, tanning is essentially a slow operation, and it cannot be forced through without injury to the resulting leather, any more than can the operations of roasting beef or toasting bread be hastened unduly. The many processes which have been suggested, involving chiefly the use of strong tan liquors, or ooze as it is technically called, and the transfusion

of these liquors through the hides, have resulted generally in the production of hard and intractable leather, or of a superficial tanning only. Such imperfectly made leather gets an appearance of uniformity and finish by being impregnated with grape-sugar, or with sulphate of magnesia, chloride of barium and other salts, which add weight, but which otherwise are the most rank and deleterious adulterants.

In the treatment of ox-hides for the production of, say, sole-leather, the first object of the tanner is to clean and soften the hide. This is done by washing with water, and if necessary working the hide under stocks till the whole is uniformly soft and pliant. The unhairing and removal of the scarf skin is the next operation, for which in English tanneries the hides are steeped in pits containing lime-water, while in America the plan adopted consists of sweating the hides, or artificially heating them till incipient

putrefactive fermentation is set up. The hides are afterwards stretched over a tanner's beam, and the hair and scarf skin are removed by shaving with a fleshing-knife. At the same time the flesh side is gone over, and any fragments of fibre or fat adhering to it are pared away. All traces of lime in the hides must be got rid of, and that sometimes is effected in the first tan-pit, containing acid liquors weak in tannin, and sometimes by 'bating' in 'pure'—which is a warm decoction of pigeons' or other fowls' dung. The *modus operandi* of actual tanning varies endlessly, but in general it may be said to consist in suspending or depositing in layers the hides in a successive series of pits containing tan liquor or ooze which is weak at first, but which as the tanning proceeds is made increasingly rich in

tannin. In the early stages of the tanning the hides are frequently handled or turned over in the tan-pits, as often as two or three times daily at first; but as the tanning progresses this handling becomes less and less frequent, till in the final pits, in which strong liquor is used, and where, moreover, the hides are interstratified with raw bark, they may rest for six weeks without being disturbed. When finally taken from the tan-pit the hides are carefully drained in a heap covered over from the light, after which they are suspended in the loft for drying, in which condition they form rough leather, hard, uneven, and refractory. To finish the hides they are damped and softened in water, scoured to remove the bloom from their surface, then liberally oiled and the whole surface worked over by pressure with a three-sided steel implement called a striking-pin. This operation removes all creases and smooths out and solidifies the leather—an operation carried further and finished after renewed oiling, by rolling the hide on a smooth floor under a heavy hand-roller. For both these operations very efficient machinery is now generally substituted for the old method of hand labour. The different portions of an ox-hide, and of all hides in some degree, possess distinct qualities which render them available for special applications; hence in the trade they receive distinctive names, and frequently are separately dealt in. An entire hide is termed a *crop* (see fig.); one-half the crop cut longitudinally forms a *side*; the pieces around the margins are designated as on the diagram, and collectively form the *offal*; the neck and shoulders are sometimes detached from the *butt*, which forms the hide minus the *offal*, and half a butt cut lengthways makes a *bend*.



Ox-hide or Crop.

Dressed Leather.—Under this head there is embraced a great range of leathers which after tanning undergo a varied series of finishing operations at the hands of the currier and leather-dresser, to fit them for the diverse uses to which dressed

leather is applied. The currier has to do with the paring down of the flesh side of the leather, to smooth its surface, and to equalise its thickness; and he also, when desirable, splits hides by means of a machine into two or more useful layers or splits. His further and principal operations have for their objects the rendering of the leather soft, flexible, and waterproof, and giving it the finished surface, grained or smooth, waxed or blackened, glazed or enamelled, dyed, &c. For stuffing the leather, which is the most essential operation of the currier, it is first softened in water, then the surface is gone over with a scraping tool or slicker, and while still wet it is liberally covered with a dubbing composed of mixed tallow and cod-oil. As the moisture evaporates from the leather the grease penetrates and thoroughly permeates the whole texture. For the numerous operations of currying and finishing leather elaborate machinery is now employed, which has almost entirely superseded hand work.

Morocco leather is a term which now applies rather to the finish of a certain class of goods than to the source of the skin of which it is formed. It is a richly grained and dyed leather, originally and properly made from goat-skins tanned in sumach; but now sumach-tanned split calf-skins and sheep-skins are the source of much so-called morocco. Sheep-skins roughly tanned and undressed are termed basils; dressed and dyed as for morocco, but finished smooth, they form roans; and split sheep-skins (the flesh sides of which go to be shamoyed to form wash-leather) tanned and dressed are known as skivers. Russia leather is now any smooth finished thin leather, impregnated with the empyreumatic oil of birch-bark, which gives the substance its peculiar odour and insect-resisting qualities. Originally it was made in Russia of dressed calf-skins.

Tawing consists in dressing skins with certain mineral salts, and is useful principally for glove leathers and the so-called kid-leather employed for the uppers of ladies' boots. It is also by tawing that furriers' skins are prepared, and hides and skins in the hair generally preserved. The process of tawing a lamb-skin may be taken as a typical example of the process, which, however, is much varied, as experience suggests. The skins are generally limed on the flesh side with cream of lime to detach the wool, which is removed as in ordinary hide-tanning. After thorough cleansing, the pelts are steeped for two or three weeks in a pit filled with water and lime, being taken out from time to time, and drained on sloping benches. When removed finally from the lime-pit, the skins are worked with the knife, to render them still more supple, and they are then put into the branning mixture. This consists of bran and water, in the proportion of two pounds of bran to a gallon of water. From this mixture, in about two days, they are transferred to another bath, consisting of water, alum, and salt. After the proper amount of working in this mixture, they undergo what is called the pasting, if intended to form white leather. The paste is a mixture of wheaten-bran and sometimes flour and the yolks of eggs. They are usually worked in a rotating cylinder with this paste and water, and are found in time to have absorbed the paste, leaving little more than the water. If the skins are not intended to be white, other materials are often used, and much pigeons' and dogs' dung is employed. Lastly, the skins are dried and examined, and, if necessary, the pasting is repeated; if not, they are dipped into pure water and worked or staked by pulling them backwards and forwards on what is called a stretching or softening iron, and smoothed with a hot smoothing-iron. Numerous other tawing processes are in use and have been suggested, one of

the most promising of which was the chrome tanning of Dr Heinzerling, introduced about 1876. In this the active agent is bichromate of potash; after treatment with which the leather is stuffed with paraffin; but the expectations of the promoters of this method of treating leather have not been fulfilled, the demand for chrome-tanned leather appearing to have quite fallen away.

Shamoying consists simply in impregnating and saturating skins with oil. The name is derived from the fact that the process was originally applied for the preparation of the skins of the Alpine chamois, and as it was also used for other deer-skins the name buck-leather or buckskin was also given to the preparation. Shamoy-leather now consists principally of the flesh splits of sheep-

skins. The oil is worked by means of stocks slowly into the interstices of the skin and there becomes oxidised, forming a kind of combination with the gelatinous constituents, and yielding a peculiarly soft and spongy texture. A good deal of the buff-leather of commerce is prepared by a process which partakes of the features of both tawing and shamoying.

Lenses. A lens is a piece of glass so shaped as to refract rays of light really or apparently radiating from a point, and make them deviate so as to pass, or to travel on as if they had passed, through another point. Every system of lenses, however complicated and whatever be the mutual distances of the lenses, will, if the whole be centred on a common axis, produce a real image somewhere in front of, or else will appear to produce a virtual image somewhere behind, the last refracting surface. The rays on being traced through the complex combination—e.g. a telescope—undergo numerous deviations; ultimately there is a deviation which might have been equally produced by an *equivalent lens*; equivalent, however, in no other sense than as producing an equal ultimate deviation, for the image is not formed in the same place as the single 'equivalent lens' would have formed it. The system of lenses is approximately equivalent in its action to a simple lens *plus* a determinate shifting of the focus. Hence a simple lens-diagram, modified so as to represent this shifting, will represent the aggregate effect of the most complex system of lenses. When the subject was looked at from this point of view it was found by Gauss, followed up by Listing, that the whole theory of lenses can be treated generally; the most complex system of lenses can be replaced in every case by a region of space traversed by the common axis of the lenses, at right angles to which axis there are six characteristic planes, the relative positions of which to some extent depend upon the refracting media and their forms and mutual distances, but which also present certain invariable properties and mutual relations. These six planes are (1) the incidental focal plane (F, fig. 1); (2) the incidental principal plane, P, and (3) the incidental nodal plane, N; (4, 5, and 6) the refractive principal, nodal, and focal planes, P', N', and F'. The principal properties of these planes are: all pencils of rays

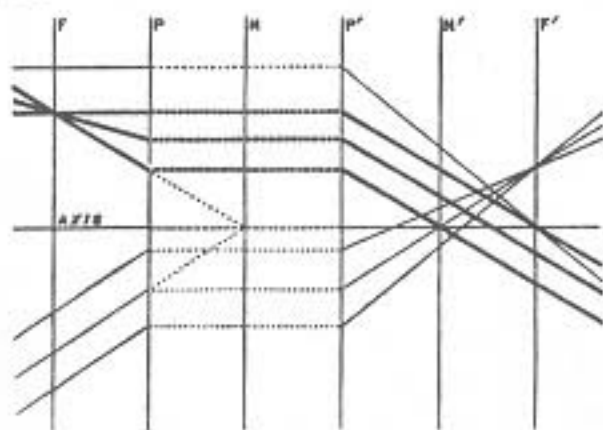


Fig. 1.

converging from any point on the incidental focal plane F (provided in this as in all other cases that no ray is so far from the axis as to give rise to spherical aberration) emerge parallel to one another; conversely, all rays incident parallel to one another come to a focus at a point in the second focal plane F'. An object on one principal plane, P, has an equal-sized image on the other, P'. Any ray appearing on incidence to make for the point where one nodal plane, N, cuts the axis, emerges parallel to its former course, but apparently coming from the corresponding point in the second nodal plane, N'. Rays arriving parallel to the axis pass on emergence through the axial point of the focal plane F'; rays passing through the corresponding point in plane F emerge parallel to the axis. These axial points are the foci of the lens-system. These properties are diagrammatically shown, with exaggeration of the distances of the rays from the axis, in fig. 1.

In this diagram the six planes are represented as equidistant; they are generally not so; their position has to be calculated. The calculation (see Pendlebury, *Lenses and Systems of Lenses*) necessitates the use of standard formulae involving continued fractions; the physical principle underlying these is that the image (real or virtual)

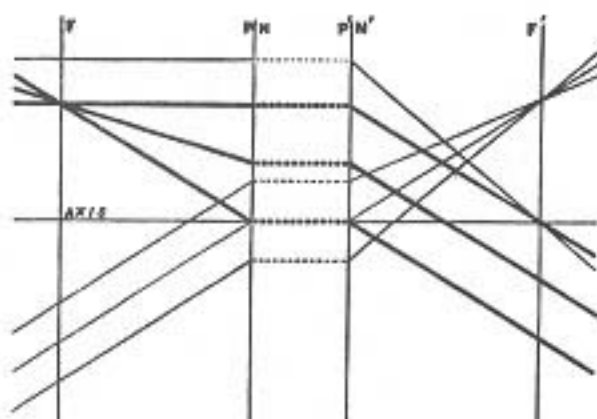


Fig. 2.

produced by one refracting surface is taken as the object of the next, and so on in succession until the position and deviation of the emergent rays is established. The fixed relations between the mutual distances of these planes are: $FN = P'F'$; $F'N' = PF$; and $PF = P'F'/\mu$, where μ is the ratio between the refractive index of the final and that of the original medium. The matter is greatly simplified when, as in the ordinary case, the final and the original media are the same (lens or telescope in air); then $\mu = 1$, each nodal plane coincides with the corresponding principal plane, and $FP = F'P'$. The diagram takes the form indicated by fig. 2. If we come now to the simplest case, that of a single thick lens in air (fig. 3), the standard formulae, according to this method, are $AF = -\mu r' - (\mu - 1) \frac{t}{\Delta(\mu - 1)}$; $A'F' = \mu r' - (\mu - 1) \frac{t}{\Delta(\mu - 1)}$; $AP = -\frac{t}{\Delta}$; $A'P' = -\frac{t}{\Delta}$ and $PF = -P'F' = -\frac{\mu r' t}{\Delta(\mu - 1)}$; where Δ stands for $\{\mu(r' - r) + (\mu - 1)t\}$. In these formulae r is the radius of the A surface, measured towards the centre and towards the right; r' that



Fig. 3.

of the A' surface, measured in the same way; t is AA', the thickness of the lens; μ is its refractive index as compared with that of the surrounding medium (air) = 1. As an example, let us apply these formulae to a biconvex lens of crown-glass, $\mu = 1.500$; let the radii be $r = +4$ inches at A and $r' = -6$ (negative because measured to the left) at A'; and let the thickness be 1 inch. Putting these numerical values instead of the letters in the formulae, we get $AF = -4.69$ inches; F is 4.69 inches from (to the left of) the A surface. $A'F' = +4.55$ inches; F' is 4.55 inches from A'. $AP = +0.28$; the principal plane is to the right of A, inside the lens. $A'P' = -0.41$; the second principal plane is to the left of A', inside the lens. The two principal planes are therefore both inside the lens, 0.31 inch apart, and are nearer the more curved face of the lens. The distance $FP = F'P'$, between either focus and the corresponding principal plane, is 4.96 inches, and this is the focal distance or the focal length of the lens; this, not the distance between the focus and the centre or the surface of the lens. The two focal distances are equal; hence if we could by reversing the lens make the principal planes exchange places, the action of the lens would be the same in both positions; but this cannot be done with an unsymmetrical thick lens by simply reversing it in its setting, on account of the unsymmetrical position of the planes within the lens. If we take the ten



Fig. 4.

cases in which the lenses are respectively: (1) biconvex (r positive, r' negative; equiconvex if $-r = r'$); (2) plano-convex ($r = \infty$ and $1/r = 0$; r' negative); (3) convexo-plane ($r +, r' = \infty$;

$1/r' = 0$); (4) biconcave ($r -, r' +$); (5) plano-concave ($r = \infty, r' +$); (6) concavo-plane ($r -, r' \infty$); (7) convex meniscus ($r +, r' +, r'$ greater than r); (8) concave meniscus ($r -, r' -, r$ numerically greater than r'); (9) concavo-concave ($r +, r' +, r$ greater than r'); (10) concavo-convex ($r -, r' -, r$ numerically greater than r')—we find, on giving the proper signs to the respective terms in the standard formulae above, that in lenses with a flat face one of the principal planes coincides with the vertex of the curved surface; that in all double concave and practically in all double convex lenses the principal planes are within the lens itself; that in lenses 7 and 8 the planes lie outside the convex face until the concave face is flattened so far as to draw one of them upon the lens; and that in lenses 9 and 10 the planes lie outside the concave surface until its curvature increases so far as to draw the nearer plane into the lens. We also find that in all simple lenses whose edges are thinner than their centres PF is negative (i.e. F is to the left of P), and the lens makes parallel rays incident upon it to converge upon some point in the opposite focal plane; while in thick-edged lenses PF is positive and P'F' negative, and the planes lie in the order F'PP'F, those rays which were parallel before incidence being divergent on emergence, and holding a course as if they had come from some point on that focal plane which lies on the same side of the lens as the source itself. When the incident rays are parallel to the axis and to each other, on emergence they converge really upon the opposite focus of a thin-edged lens or appear to diverge from the virtual focus of a thick-edged lens.

When the incident rays diverge from a point not on the focal plane they come to a focus at a definite point elsewhere than on the second focal plane.

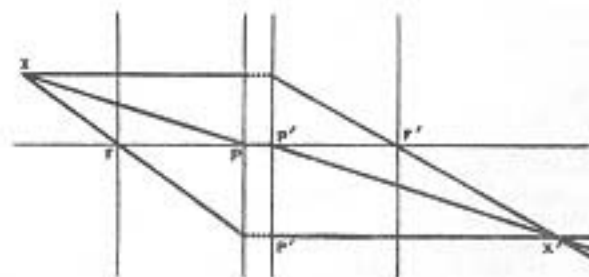


Fig. 5.

Fig. 5 diagrammatically illustrates this for a convergent lens. A pencil from X converges on X'; the geometry of the figure shows (by similar triangles) that $FP/XP + F'P'/X'P' = 1$. Hence, if PF or P'F', the focal length, be written f , and the distances XP and X'P' be written d and d' , then, numerically, $f(1/d + 1/d') = 1$. Fig. 6 illustrates

the same thing for a divergent lens: $FP/XP - F'P'/X'P' = -1$, or, numerically, $f/d - f/d' = -1$.

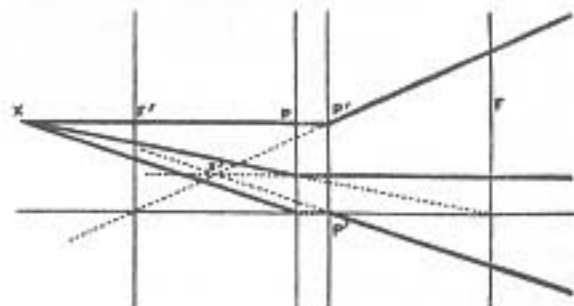


Fig. 6.

These equations give, numerically, the relations between d and d' , the distances of the object X and the image X' respectively from the corresponding principal planes P and P'. The general numerical formula which covers these relations is that if $d = XP$ and $d' = X'P'$ and $PF = P'F' = f$, f being taken as numerically negative in convergent and positive in divergent lenses, then

$$f\left\{\frac{1}{d} + \frac{1}{d'}\right\} = -1.$$

If an object occupy a plane passing through X at right angles to the axis, the corresponding image will (aberration apart) be in a similar plane passing through X'. Fig. 7 shows rays from three points

of an object passing through the nodal points P and P' and emerging parallel to their former courses.

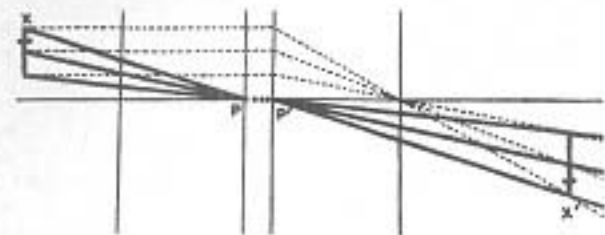


Fig. 7.

The size of the image is easily seen to be to that of the object as d' is to d . In a convergent lens the image of a distant object is inverted and real; there is a real crossing of rays in the image, and the real image is formed suspended, as it were, in space, invisible from points not in the path of the rays; a screen of card, of ground glass, or of tissue paper may be placed so as to coincide with the real image, which then becomes visible on the screen: if the eye be removed to a sufficient distance in the path of the rays the inverted real image in space itself becomes visible as an object in space between the lens and the observer, an inverted reproduction of the original object; and this inverted copy is, for all distances between the object and the lens exceeding twice the focal length, smaller than the original object, and for all such distances between twice and once the focal length it is greater than it. When the object is placed within the focal distance d is less than f , and d' is therefore numerically negative; the image is virtual; no screen will at any place receive an image; but the rays come to the eye as if they had proceeded from a larger object more remote from the lens on the original side of it; whence such lenses are commonly employed as magnifying glasses. Whenever the image formed is a real one the object and the image are interchangeable; an object placed in the position of the real image will produce a real image on a screen placed in the position of the original object. A comparison of fig. 6 with figs. 5 and 7 will show that the virtual image formed by a divergent lens is smaller than the object and is not inverted.

In all these cases the lenses are supposed to have an appreciable thickness. If, however, we assume that the thickness is negligible, the formulæ given above are modified by suppression of all terms containing t ; they become simply $PF = AF = f = -r'/(μ - 1)(r' - r)$, or $1/f = -(\mu - 1)(1/r - 1/r')$; and $AP = 0$. Whence the principal planes coalesce and blend with the surfaces; and the ordinary lens-formulæ are obtained, in which f , the focal distance, means half the distance between the two focal points. The result is only approximate, as the numerical example already discussed will show when treated in this way. There $r = +4$; $r' = -6$; $\mu = 1.500$; whence $f = -\{ \frac{1}{\frac{1}{4} - \frac{1}{6}} \}^{-1} = -4.8$ inches, and the distance between the two foci is inferred to be 9.6 inches; whereas we have previously seen this distance (including PP') to be 10.24 inches. On the assumption now made, a lens is reversible; for in the formula we find that when the radii exchange places both change their signs, the result being the same. On giving the proper signs and numerical values to r and r' in the simplified formula, it is easy to arrive at the numerical value of f for a lens of any form: if f be negative, the lens is convergent (thin-edged); if positive, it is divergent. Then, f having been found, the relation between f , d , and d' can be found by giving d and f their proper signs and numerical values in the general equation $f/d + f/d' = -1$. If we find d' negative we infer a virtual, if positive a real image. For example, a crown-glass lens ($\mu = 1.500$), biconcave; $r = -4$ inches; $r' = +4$; $1/f = -(1.5 - 1)(\frac{1}{-4} - \frac{1}{4}) = +\frac{1}{4}$; $f = +4$, a divergent lens. Object at distance, say, $d = 196$ inches; $\therefore d' = -196/50 = -3.92$ inches; a virtual image, smaller than the object in the ratio of 3.92 to 196, or one to fifty. Again, a similar lens, but biconvex; $r = 4$; $r' = -4$; $\therefore f = -4$ inches, a convergent lens. Let the object be at 204 inches; $d = 204$; $f = -4$; $\therefore d' = 4.08$ inches—a real image, smaller in the ratio of 4.08 to 204, or one to fifty. Let the object be at $d = 3\frac{1}{2}$ inches; $\therefore d' = -28$ and the image is virtual, enlarged in the ratio of 28/3.5, or eightfold, by the use of the lens as a magnifying glass. The nearer the object to the focus the greater the enlargement. To make the image

equal in size to the object, d must be equal to d' ; then $-f/d + -f/d = -1 = -2f/d$; and $d' = d = 2f$. With a convergent lens adjust the positions so that the object and its image on a screen are of the same size; then they are at a distance of four times the focal length from each other. In this way, neglecting the thickness, the focal length of a convergent lens may be ascertained. It may also be ascertained by means of an object (spider-threads or a piece of muslin), and a telescope focussed for a very distant object; direct the telescope towards

the spider-threads; interpose the lens to be examined; shift it until the spider-threads are distinctly seen in the telescope; the spider-threads are then in the focus of the lens, which causes the rays from them to pass parallel into the telescope. A divergent lens has its focal length measured by conjoining it with a convergent one, which neutralises or overbalances its effect: if $-F$ be the focal length of the convergent combination, $-f$ that of the convergent lens, and f' (unknown) that of the divergent lens, $-\frac{1}{f} + \frac{1}{f'} = -\frac{1}{F}$; the deviation produced by a lens is inversely proportional to its focal length, and the equation states the proposition that the convergence produced by the one, together with the divergence produced by the other, is equal to the convergence produced by the combination.

When the light from an object is mixed the refractive index μ differs for each colour; the distance of the image is different for each spectral colour; thus a series of images are formed behind one another, the violet in front and the red behind; those behind are larger and overlap, and therefore the image appears to have a spectral fringe of colour, red outside. To prevent this chromatic aberration images of two or more colours, say the blue and orange, should be brought to the same plane and be of the same size; this is done for two colours or wave-lengths by combining a crown-glass convergent of excessive power with a flint-glass divergent lens; the curvatures are so chosen that the spectral dispersion produced by the one is compensated by the re-combination produced by the other; but, since in the two materials the refractions and dispersions are not proportional to one another, there remains a balance of deviation accomplished without chromatic dispersion. Newton thought dispersion and deviation to be always proportional to one another, and achromatism therefore impossible; Dr Hall in 1733 found this not to be so, and made achromatic lenses, but did not publish his discovery. Dollond in 1757 first introduced achromatic lenses. When two colours are achromatised there is still some chromatic aberration as regards the rest; to bring a greater number of colours to the same focus requires a greater number of refracting surfaces.

In all the preceding it has been assumed that the lenses are narrow, or that the pencils of rays fall on the centre of the face, and that the objects are small. When the object is viewed by the lens under a wide angle a plane object gives an ellipsoidal, paraboloidal, or hyperboloidal image, which, when real, cannot be wholly received in focus upon a plane screen; and oblique rays fail to converge upon precise points, and hence, even on a screen so curved as to receive the oblique pencils of rays when at their greatest concentration, the image will not be equally distinct all over. Further (spherical aberration), if the lens be too wide, or its curvature too considerable, the rays falling on different zones of the lens are, as it were, received by prisms of different angle; those incident on exterior zones are more sharply refracted than those nearer the axis, and their focus lies at a point some distance nearer the lens than the geometrical focus (longitudinal aberration), and the image is thus distorted, so that the image of a square object formed by a single convex lens appears to be drawn out at the corners, and that formed by a concave lens appears to have its corners squeezed in; besides which there is blurring, for pencils incident near the edge have their foci not even on the axis, but short of it. To remedy these defects, which cannot all be thoroughly dealt with at the same time, various 'aplanatic' combinations of lenses of different curvatures have to be employed to build up a compound 'equivalent lens'; and these combinations have to be adapted to the particular purpose for which the lens-system is to be used (see Parkinson's and Coddington's *Optics*). The property of refracting light-rays possessed by lenses necessarily applies also to heat and actinic rays;

whence the use of lenses as burning-glasses (in which parallel heat-rays from the sun are brought to a focus at the principal heat-focus of the lens) and photographic lenses. The heat-focus is somewhat farther, the actinic focus somewhat nearer to the lens than the light-focus is; but, by the application of the principles of correction for chromatic aberration, the visual and the actinic forms are, in the last case, made to coincide.

Lentil (*Ervum lens*), an annual plant belonging to the natural order Leguminosæ. It is a native of the countries bordering on the Mediterranean, and has been cultivated from the very earliest times. In Egypt and Syria it is still made into pottage, and another favourite mode of cooking it in those countries is by parching it in a frying-pan. The lentil is extensively cultivated in the warmer parts of Germany, France, and the south of Europe generally. It is also cultivated to some extent in Asia. The Hindus, in common with the Egyptians, regard it as the best food on which to undertake long journeys or laborious work. Flour of lentils is highly nutritious and contains, according to Playfair, more nitrogenous matter than any other edible leguminous plant. Einhoff found in 3840 parts of lentils 1260 parts starch and 1433 parts analogous to animal matter. The foods known as *Revalenta arabica* and *Ervalenta arabica* (words compounded of the botanical name of lentil) are simply specially prepared forms of the flour of lentils, in no way superior to the ordinary flour which can be purchased at greatly less prices. Mixed with peas in the making of pea-soup, lentils diminish the tendency to flatulence, and lentil soup is much esteemed by vegetarians and others in Britain. By Roman Catholics lentils are eaten during Lent, both in soups and in the form of haricot, as a substitute for flesh-food. The lentil is a weak, straggling plant, rarely exceeding 18 inches high, often much more dwarfed, having pinnate leaves terminating in tendrils. The flowers are white, lilac, or pale blue, small, and formed like those of a pea. There are three varieties of lentil recognised in the countries in which it is cultivated: the small brown, which is the lightest flavoured and the best esteemed for soups and haricots; the yellow variety, which is slightly larger; and the lentil of Provence, which has seeds as large as a small pea, but is better appreciated as fodder for cattle than for the grain as food for man.



Lentil.

Lever, an inflexible rod—straight or bent, as the case may be—supported at some point of its length on a prop which is called the *fulcrum*, and having a *resistance* to be overcome and *power* to overcome it applied at other two points. The general principle governing levers of all sorts is that the power and the resistance must tend to produce opposite rotations round the fulcrum, and that their moments—the product of either of them into the shortest distance between the line of the direction of its application and the fulcrum—must be numerically

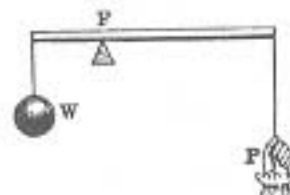


Fig. 1.

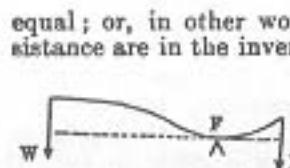


Fig. 2.

equal; or, in other words, the power and the resistance are in the inverse ratio of their respective shortest distances from the fulcrum. When this is the case there is equilibrium; when either 'moment' predominates there will be rotation. These conditions may be fulfilled whether the power P , the fulcrum F , and

the resistance W stand in the order PFW, PWF, or WPF; and hence levers are popularly divided into three classes. In the first class (PFW)—fig. 1 for a straight lever, fig. 2 for a bent one, equivalent to a straight lever since P and W are parallel—we have the Balance (q.v.), the spade (when used for raising earth), the seesaw; or, as double levers, scissors and pincers. In the second class (PWF, fig. 3) we have crowbars (P the hand, W the resistance of the body pushed, F the ground), boat-oars (P the hands, W at the rowlock, the resistance of the boat, F the comparatively fixed position of the oar-tip in the water), wheelbarrows; and, as double levers, nutcrackers (P the hand, W the nut, F the hinge).

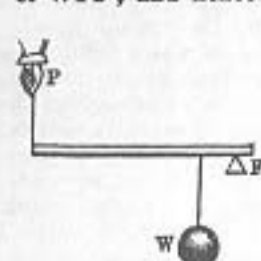


Fig. 3.

In the third class (WPF, fig. 4) we have fishing-rods, whips, umbrellas, and most instruments used with the hand alone, and coal- and sugar-tongs; and many instances in the muscular system—e.g. the biceps muscle and forearm of man (fig. 5), his deltoid muscle and shoulder, the pectoral muscle and wing of birds.

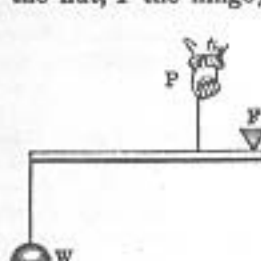


Fig. 4.

Levers of the third class always work at a mechanical disadvantage as regards power; but what is lost in power is gained in speed and range of movement—e.g. the biceps muscle, since CA, fig. 5, is about one-sixth of the distance between the elbow-joint and the palm of the hand, must exert a 6 lb. pull on A in order to raise a 1 lb. mass in the hand (setting aside the weight of the forearm itself). Levers of the second order always act at a mechanical advantage as regards power; and in those of the first order a given pressure may overcome a greater, an equal, or a less resistance, according to the ratio of the arms. A subsidiary advantage of levers of the second order is that when a man lifts weight by one of the first order his power is limited to his own weight hung on the lever, whereas with one of the second order his push or pull is upward, and he is thus able to exert his full muscular strength.

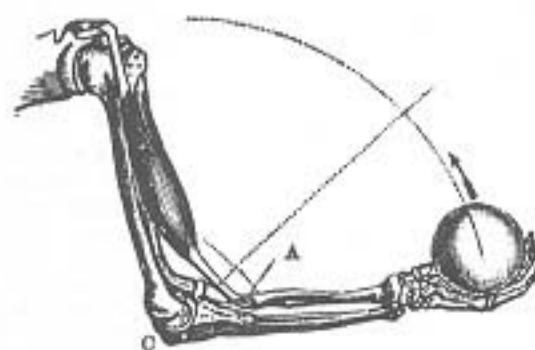


Fig. 5.

When a large mechanical advantage is required this may be obtained, without using bars inordinately long, by means of a combination of them (as in fig. 6). Here the levers have their arms in the ratio of 3 to 1, and a little consideration will make it plain that a power, P , of 1 lb. will balance the weight of 27 lb. But in this instance the particular defect of the lever as a mechanical power shows itself prominently; for if the 27 lb.

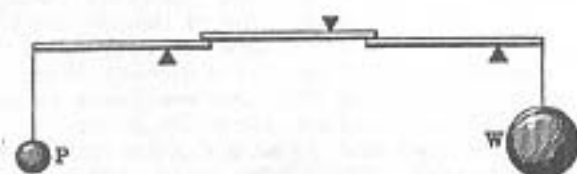


Fig. 6.

mass has to be lifted two inches, the power requires to act downwards through (2×27) or 54 inches; and, as the extent of sweep of the power cannot be largely increased without inconvenience, the advantages of this contrivance are confined within narrow limits.

Lime is the monoxide of the metal Calcium (q.v.), and is known in chemistry as one of the alkaline earths. Its symbol is CaO , its equivalent is 56, and its specific gravity is 3.08. In a state of purity it is a white caustic powder, with an alkaline reaction, and so non-fusible as to resist even the heat of the oxyhydrogen flame (see LIME-LIGHT). It is obtained by heating pure carbonate of lime (as, for instance, white Carrara marble or Iceland spar) to full redness, when the carbonic acid is expelled and lime is left. This compound, CaO , is known as *quicklime*, or, from the ordinary method of obtaining it, as *burned lime*, to distinguish it from the *hydrate of lime*, or *slaked lime*, which is represented by the formula $\text{CaO}, \text{H}_2\text{O}$. On pouring water on quicklime there is an augmentation of bulk, and the two enter energetically into combination; and, if the proportion of water be not too great, a light, white, dry powder is formed, and a great heat is evolved. On exposing the hydrate to a red heat the water is expelled and quicklime is left.

If quicklime, instead of being treated with water, is simply exposed to the air, it slowly attracts both aqueous vapour and carbonic acid, and becomes what is termed *air-slaked*, the resulting compound in this case being a powder which is a mixture of carbonate and hydrate of lime. Owing to this property quicklime is employed to prevent instruments and other objects from being rusted or otherwise injured by damp. A jar is partly filled with lime and placed beside the articles in a glass case or box.

Lime is about twice as soluble in cold as in boiling water, but even cold water only takes up about

$\frac{1}{10}$ of its weight of lime. This solution is known as *lime-water*, and is much employed both as a medicine and as a test for carbonic acid, which instantly renders it turbid, in consequence of the carbonate of lime that is formed being insoluble. It must, of course, be kept carefully guarded from the atmosphere, the carbonic acid of which would rapidly affect it. If in the preparation of slaked lime considerably more water is used than is necessary to form the hydrate, a white semi-fluid is produced, which is termed *milk of lime*. On allowing it to stand there is a deposition of hydrate of lime, above which is lime-water. Milk of lime is much used as a whitewash.

Lime prepared for building and other purposes by burning limestones in kilns often contains a considerable amount of impurity. But certain kinds of slightly impure are better than pure lime for making mortar. On the other hand, the lime which enters into the composition of plate and sheet glass, and which is used in some chemical industries, requires to be obtained from a nearly pure limestone. Chalk and white marble consist of almost pure carbonate of lime, but many of even the dark coloured limestones from different geological formations do not contain more than from 2 to 5 per cent. of foreign bodies, and these when burned generally yield a lime sufficiently pure for most purposes. Some limestones, again, contain from 20 to 30 per cent. of impurities, which commonly consist of silica, clay, magnesia, oxide of iron, and other bodies. These impure kinds often yield excellent hydraulic lime, which is very generally made by burning a limestone containing from 12 to 20 per cent. of silica, or of clay in which silica predominates. A less valuable hydraulic lime is prepared from a limestone containing a considerable amount of magnesia as well as clay. According to the absence or presence of foreign bodies, their nature and extent, limes are classed as (1) rich, fat, or pure lime; (2) impure or poor lime; and (3) hydraulic lime (see CEMENTS). When the percentage of magnesium carbonate in a limestone is high it is called a magnesian limestone, and this requires less fuel to burn it than a pure or nearly pure limestone. See DOLOMITE.

Besides the uses of lime, noticed above, it is employed in the purification of coal-gas, in the unhairing of hides for tanning, in the preparation of stearic acid for candlemaking, for causticising alkalies, in the smelting of some metals, &c. Lime precipitates organic impurities from vegetable solutions containing sugar.

The following are the most important of the salts of lime. *Sulphate of lime* (calcium sulphate) is found native free from water, CaSO_4 , as the mineral *Anhydrite* (q.v.), but more abundantly in the hydrated form, $\text{CaSO}_4, 2\text{H}_2\text{O}$, as *Gypsum*. Sulphate of lime is a constituent of sea-water, and is also frequently present in drinking-water. For laboratory use a solution of sulphate of lime is

made by shaking up the powder of burnt gypsum in water. See CALCIUM, and GYPSUM.

Carbonate of lime (calcium carbonate, CaCO_3) is abundantly present in both the inorganic and organic kingdoms. In the inorganic kingdom it occurs in a crystalline form in Iceland spar, Aragonite, and marble; while in the amorphous condition it forms the different varieties of common limestone, chalk, &c. It is always present in the ashes of plants, and it is the main constituent of the shells of crustaceans and molluscs, and occurs in considerable quantity in the bones of man and other vertebrates. See LIMESTONE; and BUILDING STONE, MARBLE.

Chloride of Calcium, CaCl_2 , is a remarkably deliquescent substance and one of the most soluble of salts on account of its great attraction for moisture. In the solid state it is much used for drying gases, and the pipes of freezing machines are filled with a solution of it to convey the low temperature produced to the cooling vessels.

There is a combination of lime with an organic acid—viz. oxalate of lime—which is of great importance in pathology as a frequent constituent of urinary calculi and sediments; for a description of it, see OXALIC ACID.

There are several compounds of phosphoric acid and lime, of which the most important is the *tribasic phosphate of lime* (tricalcium orthophosphate), sometimes termed *bone phosphate*, from its being the chief ingredient of bones. This phosphate is represented by the formula $\text{Ca}_3\text{P}_2\text{O}_8$, and occurs not only in bones, but also in the minerals apatite and phosphorite, and in the rounded nodules termed Coprolites (q.v.). It forms four-fifths of the ash of well-burned bone, the remaining fifth being chiefly carbonate of lime. This ash is known as *bone-earth*, and is employed as a manure and in the preparation of phosphorus, &c.

The soluble salts of lime give no precipitate with caustic alkalies, but yield a white precipitate with their carbonates. These reactions are also common to the salts of barium and strontium. Solution of sulphate of lime gives a white precipitate with the salts of barium and strontium. The most delicate test for lime is oxalate of ammonia, which, even in very dilute solutions, throws down a white precipitate of oxalate of lime. This precipitate is insoluble, except in mineral acids.

For the substance commonly designated as *chloride of lime*, see BLEACHING POWDER. For *lime as manure*, see MANURES.

Lime-compounds in Materia Medica.—Quicklime, in association with potash, either as the *Potassa cum calce*, or as *Vienna Paste*, is occasionally used as a caustic. *Lime-water*, mixed with an equal quantity or an excess of milk, is one of our best remedies for the vomiting dependent on irritability of the stomach. From half an ounce to two or three ounces may be thus taken three or four times a day. Its use as a constituent of Carron oil in burns is noticed in the article LINIMENTS. *Chalk*, or *carbonate of lime*, when freed from the impurities with which it is often associated, is used as a dusting-powder in moist excoorations, ulcers, &c.; and, in the form of *chalk mixture* and *compound powder of chalk*, is a popular remedy in various forms of diarrhoea. A mixture of an ounce of precipitated carbonate of lime and a quarter of an ounce of finely-powdered camphor is sold as *Camphorated Cretaceous Tooth-powder*.

Lime-light, light produced by a blowpipe-flame directed against a block of pure, compressed quicklime. The lime, which ought to be warmed beforehand, becomes brilliantly incandescent. The blowpipe-flame may be produced in various ways: (1) blowing oxygen through a spirit flame—light obtained, about 150 candles; (2) oxygen under pressure, and coal-gas from the mains, brought in concentric tubes to a nozzle, where the mixture is burned in a fine jet—light, about 200 candles; (3) oxygen and coal-gas, both under pressure—light, about 400 candles; (4) the same, the coal-gas or the oxygen saturated with benzoline or ether or both benzoline and ether—light, up to 800 candles when both are employed; (5) warm oxygen, saturated with benzoline, gives light up to 1350 candles; (6) oxygen and hydrogen, up to about 800 candles. The mixed gases at the nozzle are explosive, and the greatest care must be taken to see that the flame is not allowed to run back or the mixture to take place elsewhere than at the nozzle. In the case where oxygen is saturated with combustible material the apparatus is so stuffed as not to

allow an explosion to travel backwards in it. Lime-light was used on the stage as far back as 1837-38, but was greatly improved in 1851-52, when *Azæol* was produced at Drury Lane.

Liniments (from the Latin word *linire*, 'to besmear') may be regarded, in so far as their physical properties are concerned, as ointments having the consistence of oil, while, chemically, most of them are *soaps*—that is to say, compounds of oils and alkalis. In consequence of their slighter consistence, they are rubbed into the skin more readily than ointments. Among the most important of them are: *Liniment of Ammonia*, popularly known as *Hartshorn and Oil*, which is prepared by mixing and shaking together solution of ammonia and olive-oil, and is employed as an external stimulant and rubefacient to relieve neuralgic and rheumatic pains, sore throat, &c.: *Soap Liniment*, or *Opodeldoc*, the constituents of which are soap, camphor, and spirits of rosemary, and which is used in sprains, bruises, rheumatism, &c.: *Liniment of Lime*, or *Carron Oil*, which is prepared by mixing and shaking together equal measures of olive or linseed oil and lime-water; it is an excellent application to burns and scalds, and from its general employment for this purpose at the Carron iron-works has derived its popular name: *Camphor Liniment*, consisting of camphor dissolved in olive-oil, which is used in sprains, bruises, and glandular enlargements, and which must not be confounded with *Compound Camphor Liniment*, which contains a considerable quantity of ammonia, and is a powerful stimulant and rubefacient; and the *Opium Liniment*, which consists of soap liniment and tincture of opium, and is much employed as an anodyne in neuralgia, rheumatism, &c. These are the chief liniments according to the old definition, but the term has gradually come to be applied to tinctures intended for external use. Such are the liniments of aconite, belladonna, cantharides, iodine, &c., which are made by treating the drugs with alcohol, and thus obtaining a concentrated tincture.

Linseed, the seed of flax, largely imported from the Continent and India, for making *linseed-oil* and *oil-cake*. In making these the seeds are first bruised or crushed, then ground, and afterwards subjected to pressure in a hydraulic or screw press, sometimes without heat, and sometimes with the aid of a steam heat of about 200° (93·4° C.). *Linseed-oil* is usually amber-coloured, but when perfectly pure it is colourless. It has a peculiar and rather disagreeable odour and taste. It is chiefly used for making varnishes, paints, &c. That made without heat (*cold-drawn linseed-oil*) is purer, and less apt to become rancid, than that in making which heat is applied. By cold expression the seed yields from 18 to 20 per cent., and with heat from 22 to 27 per cent. of oil. *Linseed-oil* boiled, either alone or with litharge, white lead, or sulphate of zinc, dries much more rapidly on exposure to the air than the unboiled oil; and *boiled* or *drying oil* is particularly adapted for many uses.—The *Oil-cake* (q.v.) made in expressing linseed-oil is very useful for feeding cattle. *Linseed* itself is excellent food for cattle and for poultry. The seed coats abound in mucilage, which forms a thick jelly with hot water, and is very useful for fattening cattle.—*Linseed-meal*, much used for poultices, is generally made by grinding fresh oil-cake, but it is better if made by grinding the seed itself.

Lint was the name given to linen cloth or rags when shredded or scraped down so as to form a soft material, suitable for dressing wounds and soaking up discharges. This is now superseded by a cotton cloth specially woven for the purpose, with one side soft and fluffy. See also **FLAX**.

Liqueur. This name is given to the very numerous alcoholic preparations which are flavoured or perfumed and sweetened to be more agreeable to the taste. *Aniseed Cordial* is prepared by flavouring weak spirit with aniseed, coriander, and sweet fennel seed, and sweetening with finely-clarified syrup of refined sugar. *Clove Cordial* is flavoured with cloves, bruised, and coloured with burnt sugar. *Kummel* (a Russian and German liqueur, named from the German name of the herb cumin) is made with sweetened spirit, flavoured with cumin and caraway seeds, the latter usually so strong as to conceal any other flavour. It is chiefly made at

Riga. *Maraschino* is distilled from cherries bruised, but, instead of the wild kind, a fine delicately-flavoured variety called *Marasques* are used in Dalmatia. *Noyau*, or *Crème de Noyau*, is a sweet cordial flavoured with bruised bitter-almonds. *Peppermint* usually consists of the ordinary sweetened gin, flavoured with the essential oil of peppermint, which is previously rubbed up with refined sugar. *Chartreuse*, *Curaçoa*, and *Kirschwasser* are described under their own names.

Liquorice (*Glycyrrhiza*), a genus of perennial herbaceous plants of the natural order Leguminosæ, sub-order Papilionaceæ, having long, pliant, sweet roots, and generally creeping root-stocks; pinnate leaves of many leaflets, and terminating in an odd one; flowers in spikes, racemes, or heads; a 5-cleft, 2-lipped calyx, and a 2-leaved keel. The ancient Greek name, now the botanical name, signifies *sweet root*, and from it, by corruption, liquorice and other modern names are derived. The roots of liquorice depend for their valuable properties on a substance called *Glycyrrhizine*, allied to sugar, yellow, transparent, uncrystallisable, soluble in both water and alcohol, and forming compounds both with acids and with bases. They are a well-known article of materia medica, and were used by the ancients as in modern times, being emollient, demulcent, very useful in catarrh and irritations of the mucous membrane.—The roots of the Common Liquorice (*G. glabra*) are chiefly in use in Europe. The plant has stems 3 to 4 feet high, and racemes of whitish violet-coloured flowers. It is a native of the south of Europe and of many parts of Asia, as far as



Liquorice (*Glycyrrhiza glabra*):
a, root.

China. It is cultivated in many countries of Europe, chiefly in Spain, and to some extent at Mitcham in Surrey and at Pontefract in Yorkshire. The roots are extensively employed by porters, brewers. They are not imported into Britain in considerable quantity, but the black inspissated extract of them (*Black Sugar* or *Stick Liquorice*) is largely imported from the south of Europe, in rolls or sticks, packed in bay-leaves, or in boxes of about 2 cwt., into which it has been run. Liquorice is sometimes used in the manufacture of sweet tobacco. Liquorice is propagated by slips; and after a plantation has been made almost three years must elapse before the roots can be dug up for use. The whole roots are then taken up. Liquorice requires a deep, rich, loose soil, well trenched and manured; the roots penetrating to the depth of more than a yard, and straight taproots being most esteemed. The old stems are cleared off at the end of each season, and the root-stocks so cut away as to prevent overgrowth above ground next year. The plant is propagated by cuttings of the root-stocks.—The roots of the Prickly Liquorice (*G. echinata*) are used in the same way, chiefly in Italy and Sicily, Russia, and the East.—The only American species is *G. lepidota*, which grows in the plains of the Missouri.

Lithic Acid. See URIC ACID.—*Lithic Acid Diathesis* is the term employed in medicine to designate the condition in which there is an excess of lithic (or uric) acid, either free or in combination, or both, in the Urine (q.v.).

Lithium (sym. Li; equiv. 7·0; sp. gr. 0·5936) is the metallic base of the alkali *lithia*, and derives its name from the Greek word *lithos*, 'a stone.' It was discovered by Arfvedson in 1817 in some Swedish minerals; but since the introduction of spectroscopic research it has been found to be widely present in many mineral waters, in the ash of plants, &c. The metal is of a white, silvery appearance, and is much harder than sodium or potassium, but softer than lead. It admits of being welded at

ordinary temperatures, and of being drawn out into wire, which, however, is inferior in tenacity to leaden wire. It fuses at 356° (180° C.). It is the lightest of all known solids, its specific gravity being little more than half that of water; it decomposes water at ordinary temperatures. It burns with a brilliant light in oxygen, chlorine, and the vapours of iodine and bromine. It is easily reduced from its chloride by means of a galvanic battery. When lithium is burned in air it forms an oxide, lithia, Li₂O, along with a trace of a higher oxide. This oxide, when treated with water, yields a hydrate, LiOH, having alkaline properties and resembling soda and potash. Lithia forms a series of salts (carbonate, chloride, citrate, &c.) analogous to the potash and soda salts, and all of these, when placed in the flame of a Bunsen burner and examined with the spectroscope, show characteristic red bands by which their presence can always be ascertained.

In medicine the salts of lithia hold a high place as solvents of uric acid. The carbonate and citrate are used for this purpose, and are said to be much more efficient in cases of gout and gravel than the potash salts.

Lithography (Gr. *lithos*, 'a stone,' and *graphein*, 'to write'), the art of printing from stone, and one of the most important of the reproductive arts, was invented in 1796 by Aloys Senefelder (1771-1834). In that year a piece of music—Senefelder's first work—was printed from the stone, and in 1800 he patented his invention in Bavaria, most of the German states, and Austria. Afterwards he opened establishments in London and Paris, but did not succeed very well. The great secrecy and jealousy with which the new art was guarded by its patentees prevented progress being made, and it was not till many years afterwards that their complicated manipulation became sufficiently simplified for the rapid advance which then became possible. Senefelder, on whom the king of Bavaria settled a pension, lived to see his invention brought to complete perfection.

The principles on which lithography is founded are (1) the strong adhesion of greasy substances to calcareous stone; (2) the affinity of one greasy body for another, and their antipathy to water; (3) the facility with which calcareous stone imbibes water. It follows that, if a greasy line be drawn on a prepared stone, its adhesion is such that it can only be erased by entirely removing the surface of the stone so far as the grease has penetrated. If water be put on the surface of the stone it remains on those parts not covered with grease; a roller charged with greasy ink may then be passed over the stone, the ink adhering to the greased portions, while the parts wet with water will repel the ink and remain clean. A piece of paper put on the stone, if pressure be applied, will receive an impression in ink of the greasy line. The covering of the stone with a solution of gum-arabic (to be afterwards described) is an almost indispensable aid to the water in resisting the ink.

There are various methods employed in lithography—drawing on stone with pen or brush with liquid ink; drawing on paper, and transferring to stone; engraving on stone; drawing on stone with crayons or solid ink, transferring from engraved plates or woodcuts, &c. These differ only in the manner of applying the greased drawings to the surface of the stone. The printing from them is in nearly all cases identical.

The Stones.—The immense quarries of Solenhofen in Bavaria furnish the best stones; others of inferior quality are obtained in France and Italy. The stones are composed of lime, clay, and siliceous earth, and are of various hues, from a pale yellowish-white to a light buff, reddish, pearly, blue, and greenish colour. Those of a uniform gray colour are the best. They are found in beds, commencing with layers of the thickness of paper; the thickness required for printing-stones being from about 2 to 4 or 5 inches. When in the quarry they are soft and easily cut to any required size. They are afterwards ground face to face with sand and water, and when quite level polished with pumice-stone, and finally with smooth polishing stone. Sheets of zinc faced with thin coatings of artificial stone have been introduced, but not as yet with much success.

The writing and drawing inks and crayons are composed of lard, hard soap, white wax, shell-lac, Venetian turpentine, carbonate of soda, and Paris black. The proportions used and the methods of manufacture vary considerably. All

descriptions can be purchased ready prepared. The greasy ingredients are the important parts; the black is only added to enable the artist to see the effect he is producing as he goes on.

Writing or drawing on stone is performed with a fine pen or brush, or a ruling pen for straight lines. The ink is rubbed down with a little water and under gentle heat, in the same manner as China ink, and the subject may be traced as for a drawing on paper. Great care is necessary in handling the stone, as its affinity for grease is so keen that a finger-mark would develop into a black blot in printing. When the drawing is finished it is covered over with a solution of gum-arabic in water. This gumming fills up the pores of the stone on the undrawn parts, and prevents the greasy lines of the drawing from spreading. The stone is then removed to the printing-press and prepared for printing. The gum is first washed off with clean water, enough remaining in the pores of the stone, however, to assist the water to resist the ink in the subsequent printing. The stone is then damped with a canvas cloth, and a roller (made of wood or iron, covered with one or two thicknesses of flannel and an outer covering of fine leather) charged with printing-ink is passed over the stone till every part of the drawing is thoroughly inked. Any accidental grease or finger-marks will now become visible, and must be removed with acid, scraping with a knife, or polishing with polishing stone. When the drawing is made satisfactory the stone is washed over with a weak solution of nitric acid in gum-water. This *etching*, as it is called, is a very important operation. If applied too strong the acid would remove the drawing completely from the stone; but when diluted to

the proper strength it gently eats away the surface of the bare parts of the stone, opening up the pores for the better reception of the gum to be afterwards applied, thoroughly cleans it from grease-soils, and sharpens the lines of the drawing. When the stone is sufficiently etched the acid is washed off and another coating of gum applied; when this is dry it is again washed off, and, usually, to clean the stone from the drawing-ink, the surface is washed with turpentine. For all that can be now seen on the stone the work is quite lost; but it is only the black ink that is washed off; the *grease* lines are in the stone, which is all that is necessary. The stone is now damped with a cloth and inked with a roller till all the drawing is black again; a piece of paper is placed on the top, passed through the press, and when taken off has received an impression of the drawing. The damping and inking is repeated for every impression, and when the stone is put away or left for a time it is, for preservation, covered with the indispensable gum, which is again washed off when printing is resumed. The ink for black printing is composed of Paris black, ground up with varnish made from boiled linseed-oil.

Writings and drawings made on prepared paper and transferred to stone for printing are, perhaps, the most important items in general lithographic work. The transfer paper is prepared on one side with a coating of isinglass, flake-white, and gamboge, and afterwards smoothed by passing several times through a press over a heated stone. The writing or drawing is made on this preparation with a pen or fine brush with the lithographic transfer ink, and when finished is transferred to the stone in the following manner. The paper is put for a few minutes between damped blotting-paper. A *warmed* polished stone is put in the press, the paper is placed with the coated side upon it, and passed several times through the press, after which the paper is damped with water and gently rubbed with the fingers till it comes easily off, leaving the drawing adhering to the stone. The stone is gummed over and proceeded with as already described. After the first inking-up, and before etching, any defects in the transfer can be touched up with a pen or brush. In France and some other countries this class of work, however, is generally either directly drawn or engraved on the stone.

Fresh impressions of lithographs, or engravings on wood, steel, or copper, and of letterpress may be transferred to and printed from the stone by the above process, the paper used being prepared with a special composition, and the ink a mixture of the writing and printing inks. Many subjects, such as music titles, &c., are engraved cheaply on zinc, expressly to be transferred to stone. When the design is small and required in large numbers, it may be transferred many times on one stone,

and many printed on one sheet of paper at every impression.

Engraving on stone, so called, is another method of putting a drawing on stone, and is as follows. A polished stone is covered with a coating of gum slightly coloured; this is afterwards roughly washed off, leaving only a very thin film of the gum, which can be easily cut through. On this ground the drawing is executed with etching-points of diamond and steel of various breadths, exactly as in etching, the surface of the stone being cut through the gum in making the lines. When the drawing is finished any greasy matter is rubbed into the lines and allowed to remain an hour or two till the stone has imbibed enough at the lines. The gum is then washed off, and the stone damped and inked and proceeded with as above, except that engraved stones are generally inked with a dauber—i.e. a piece of wood covered with one or two pieces of flannel, with which the ink is rubbed into the lines.

The following modification of this process is very useful when a photograph or drawing has to be copied in line for the stone. A thin sheet of gelatine is placed over the subject to be copied, and, it being transparent, a careful drawing may be made on it with etching-points. When finished, lithographic ink is rubbed into the lines and the gelatine placed on the stone and the drawing transferred by passing through the press. The weak point of this process is that the gelatine is apt to warp on the stone and spoil the transfer; in which case the drawing is lost.

Chalk-drawings were, before the invention of the steam lithographic press, and still on rare occasions are, drawn on grained stones. The grain, coarse or fine as required, is imparted to the stone by grinding with sand of varying degrees of fineness. The drawing is made on the stone with lithographic crayons in the same manner as the ordinary drawing chalks on ordinary crayon-paper; when finished it is proceeded with as before. Very beautiful work can be produced in this way; but as, owing to various causes which are too technical for our space, the grained stone cannot be printed at the steam-machine, and hand-press printing is too expensive for modern requirements, such work is now almost invariably executed by the *grained-paper process*. A sheet of copper or other metal is grained on the surface by aquatint, stipple, or ruling-machine; paper, coated with a white transferring ground, is passed through a press on the face of the prepared plate, becomes impressed with the grain, and may be drawn on with lithographic chalks in the same way as a grained stone. This drawing is transferred to a *flat* or polished stone in the same manner as writing or pen drawing, and printed in any lithographic press. Very good work is produced by this process, but the result of the somewhat artificial grain of the copper-plate is inferior to the beautiful grain of the ground stone. In the United States drawings are made on grained stones and impressions transferred to flat stones for printing; but this process has not found much favour in Great Britain.

Photo-lithography is a very useful method of reproducing in any size, for stone printing, existing drawings, such as architects' plans, maps, &c. A photo-negative of the required size is taken from the drawing to be reproduced, and is exposed

to light over a thin film of bichromatised gelatine on paper. The paper, after being soaked in water, which takes out the bichromate unaltered by the light, is stretched on a sheet of glass and carefully inked with a velvet roller. The ink only adheres to the parts rendered insoluble by the light, and which have remained dry during the soaking, and leaves the soluble parts, which are wet, quite clean. This is transferred to stone in the ordinary manner.

Chromo-lithography is the most beautiful of all the methods of printing from stone. The object being to produce, as nearly as possible, fac-similes of pictures in colour, it is necessary to employ a number of stones, in some cases as many as twenty or thirty, each printing a separate tint, to produce the infinite variety of colour in a finished colour-drawing. The usual method of procedure is as follows. A careful outline of the entire design is drawn on, or transferred to, a stone; from this, called the *key*, as many copies are printed as there are colour-stones required. These impressions are dusted with dry black or raddle, and, being set off on the colour-stones, form guides to the artist in drawing in the various colours; after which the key lines can be washed away with water. On one

of these stones the general effect of the picture is sometimes drawn, and this, printed in a neutral gray, forms the basis of the finished print. The other stones are drawn separately to correspond with the different colours required to produce the necessary effect. It will be easily understood that in arranging the various colours with their varying degrees of depth on the different stones, the proper amount of force to be given to each, and the effect likely to be produced by printing one tint over another, have to be considered, and give scope for a great deal of professional skill. There are many different methods of drawing the tints on the stone which are too technical for our limits. The finest work is done by stipple, drawn by hand with a fine brush, a method in which French and German artists on stone are very skilful. The colour stones are printed in the manner already described, except that coloured inks are used instead of black. The different colours, varying in number from four or five to twenty or thirty, being printed by separate impressions on the same paper, it is obvious that great care is necessary to see that every impression is exactly fitted to the others, or exactly *registered*, as it is called. Several mechanical appliances are used to secure this exactness. When the necessary number of impressions have been printed and the stone has to be cleaned for another subject, the surface must be laboriously polished down till every vestige of grease is removed.

Such is a brief outline of the different methods employed in lithography, but each method is capable of infinite number of variations in the hands of different operators.

Lithographic presses vary as much in construction as those for the letterpress. The hand-press is very simple. The stone is placed on a movable table, and a *tympan*, an iron frame covered with leather, folds down over the paper when placed on the stone. It is then rolled under the *scraper*, generally a piece of boxwood fixed in an upright, which applies the pressure. The damping and inking are done by hand.

The first self-acting lithographic machine, introduced into Britain by Sichel of Berlin and Vienna, failed from the fact that it was constructed, like the hand-press, with a scraper arrangement for the impression. This produced too much friction, rendering speed dangerous, and work difficult to keep on the stone; and it was not till about 1860 that the machine as at present in use, with a cylinder for the pressure, was introduced from France. It is somewhat an adaptation of the letterpress single-cylinder machine (see PRINTING), and a very brief description will suffice. The stone is placed on a movable bed, which can be raised or lowered according to the thickness of the stone. The sheet is fed in at the top of the cylinder, whence a gripper arrangement leads it over the stone. At one end are the damping-rollers, which are covered with some soft absorbent fabric; and at the other the inking-rollers, covered with the finest French leather, with inking-table, duct, and distributors. The stone passes first under the dampers, then to the inking-rollers, thence back to the cylinder to print the impression, and so on *ad infinitum*.

Zincography, the invention of Eberhard of Bavaria, is an application of lithography to zinc plates instead of stones, with some necessary modification of the etching and printing. Its only advantage is in connection with very large subjects, as the zinc is more portable and less liable to breakage than stone.

Lithotomy (Gr. *lithos*, 'a stone'; *tomē*, 'the act of cutting'), the technical name for the surgical operation popularly called *cutting for the stone*. As most of the symptoms of stone in the bladder (which are noticed in the article CALCULUS) may be simulated by other diseases of the bladder and adjacent parts, it is necessary to have additional evidence regarding the true nature of the case before resorting to so serious an operation as lithotomy. This evidence is afforded by *sounding* the patient—a simple preliminary operation, which consists in introducing into the bladder, through the natural urinary passage (the urethra), a metallic instrument, by means of which the stone can be plainly felt and heard.

Lithotomy has been performed in various ways at different times, both in the perineum and above the pubes. The earliest form of lithotomy is known as *cutting on the gripe*, or *Celsus's method*. It received the former name from the stone, after

being fixed by the pressure of the fingers in the anus, being directly cut upon and extracted. The *Marian method*, founded on the erroneous idea that membranous parts would not heal after incision, while their dilatation was comparatively harmless, was the operation mainly in vogue for nearly 200 years, till Frère Jacques introduced what is essentially the method now in use. Cheselden (1727) and Liston in the first half of the 19th century perhaps most deserve mention among the many surgeons who have subsequently improved upon the original operation.

The *lateral operation*, so called from the lateral direction in which the incision is made into the skin of the perineum and the neck of the bladder, in order to avoid wounding the rectum, is that which, with various minor modifications, is generally employed at the present day. Frère Jacques seems to have devised the method and to have practised it with much success; and in 1702 he published a description of it. The advantage of this operation, by which a free opening, sufficiently large for the extraction of all but very large stones, can be made into the bladder without laceration of the parts or injury to the rectum, was immediately recognised by the leading surgeons of the time, and the Marian process was at once universally given up. Other varieties of the perineal operation are termed median, bilateral, &c.

The *suprapubic or high operation* was first performed by Pierre Franco in 1561, and has occasionally been employed ever since. It has recently been proposed by some surgeons to use it in preference to perineal lithotomy in the majority of cases; but it is generally reserved for stones of large size which cannot be crushed and are difficult to remove through the outlet of the pelvis.

From the shortness of the female urethra and the extent to which it can be dilated, and, additionally, from the comparative rarity of calculous affections in women, the operation of lithotomy is seldom required in the female sex.

The danger of the operation increases with the age of the patient. Statistics of 1827 cases of lateral lithotomy in England, collected by Sir Henry Thomson, show a mortality gradually rising from 5.7 per cent. in the patients under twelve years of age to more than 31 per cent. in those over seventy. The more general adoption of lithotripsy has greatly diminished the number of cases in which lithotomy has to be resorted to.

Lithotripsy (Gr., 'stone-crushing'), the surgical operation of breaking up a stone in the bladder into such small fragments that they may readily be expelled by the urethra. Although the importance of such an operation has been recognised from the earliest time, a French surgeon, Civiale, who commenced his researches in 1817, but did not perform his first operation till 1824, may be regarded as the discoverer of lithotripsy. The instrument by which the disintegration of the stone is effected is introduced in the same manner as a catheter or sound into the bladder, and, after catching the stone, either bores, hammers, or crushes it to pieces. The stone is grasped by the blades of such an instrument as that shown in the figure, and the blades are then forcibly approximated to each other by means of a screw. The various fragments are gradually broken down in the same way till they are small enough to be discharged through a catheter introduced for the purpose.

Since the operation was first introduced, the instruments employed both for crushing the stone and for evacuating its fragments have gradually been improved; and experience has shown that this method is capable of superseding lithotomy in the adult in the vast majority of cases where an operation for stone is necessary.

It used to be considered advisable in the case of all but very small stones to crush and remove only a portion of the calculus at one time. To Bigelow of New York belongs the credit of recommending (in 1878) the method now adopted by almost all surgeons. He gave it the name of *litholapaxy* ('stone-evacuation'), but it only differs from lithotripsy in that the procedure is completed at one sitting. This improvement was an outcome of the teaching of Otis of New York, who found it possible to introduce instruments of larger size, and therefore

more effective than had been previously considered safe.

In adults the only conditions which generally make lithotripsy inadvisable are 'extreme size, with hardness of structure in the calculus itself, and confirmed narrowness or other obstruction in the urinary passages, rendering the employment of adequate instruments impossible' (Sir H. Thomson). In children the risk attending lithotomy is much less than in adults; but the difficulties of lithotripsy, in consequence of the small size of the urethra, are much greater: in boys, therefore, the former operation is still generally preferred, except in the case of very small stones.

Litmus is a well-known colouring matter, which is obtained from several lichens, but chiefly from *Lecanora tartarea*. The lichens are powdered and digested with ammoniacal fluids (urine, for example) till they undergo decomposition. Alum, potash, and lime are then added, and the mixture is allowed to stand till the maximum degree of colour is observed. Sand and chalk are added to give a due degree of solidity, and the mass is then dried in cubes, and is ready for the market. The exact nature of the changes which ensue is not altogether known; it is, however, certain that the pigment is originally red, and that it only becomes blue on the addition of alkalis or of lime. This blue colour is again changed into a red on the addition of a free acid. The use of litmus-paper and tincture of litmus for the purpose of detecting the acidity of fluids, &c. is known to every student of chemistry. See TEST-PAPERS.

Litre, the unit of the French measures of capacity, both dry and liquid. It is the volume of a cubic decimetre (see METRE), and contains a kilogramme of water at 39.2° (4° C.) in a vacuum; it is equal to 0.2200967 British imperial gallon, and is therefore less than a quart— $\frac{1}{4}$ litres being roughly equal to a gallon. The litre is subdivided decimally into the *decilitre*, *centilitre*, and *millilitre* (respectively $\frac{1}{10}$ th, $\frac{1}{100}$ th, and $\frac{1}{1000}$ th of a litre). Ten litres make a *decalitre*; 100, a *hectolitre*; 1000, a *kilolitre*. The hectolitre is the common measure for grain, and is equal to 0.3439009 British imperial quarter, or nearly $\frac{1}{3}$ imperial bushels.

Liver. The liver is the largest gland in the body. It weighs from 3 to 4 lb., and measures about 12 inches from side to side, and 6 or 7 inches from its anterior to its posterior border. It is situated in the right hypochondriac region, and reaches over to the left; being thick behind, convex on its upper surface, where it lies in the concavity of the diaphragm, and concave below, where it rests against the stomach, colon, and right kidney. This lower surface presents a fissure dividing the organ into a right and a left lobe. The liver is retained in its position by five ligaments. Besides the right and left lobes, there are three smaller lobes. The great bulk of the organ is, however, made up of the right lobe, which is six times as large as the left. The vessels of the liver are the hepatic artery, which comes off from the coeliac axis, and supplies the organ with nutrient blood; the portal vein, which conveys to the liver the venous blood of the intestines, spleen, and stomach, and from which (after the vessel has ramified like an artery) the hepatic veins arise, and convey the blood from the liver into the inferior vena cava.

In fact, the liver is a great glandular mass placed in the path of the veins passing from the stomach

venous; n, vena portæ; e, lobulus caudatus; p, lobulus Spigelii; g, inferior vena cava; r, fissure for inferior vena cava; ss, longitudinal fissure.

and intestines towards the heart. The blood, laden with nutritious matter, has to pass through the liver before it can get into the general circulation; in its passage it comes into intimate relationship with the minute hepatic cells, which alter its constitution, abstracting or adding various constituents. The bile is one of the products of the liver cells, which, obtaining their raw material from the blood, secrete this fluid into tiny ducts (drains). These join with other vessels to form larger and larger ducts (just as veins join with other veins to form larger vessels), which finally leave the liver and pass towards the gall-bladder. Here the Bile (q.v.), which is constantly secreted, is stored up ready to be discharged into the intestine during digestion. The bile, which is of a brown, or in some animals, of a green colour, is coloured by pigments (bilirubin, biliverdin), which are undoubtedly decomposition products of hæmoglobin, the colouring matter of the blood. It appears, therefore, that the red corpuscles of the blood which contain this pigment are continually suffering dissolution, probably the old and useless cells being destroyed within the body by the agency of other cells. Whether their destruction actually takes place within the liver is not yet absolutely certain, but it is certain that the liver removes their colouring matter from the system. Occasionally it happens that the liver may have a heavier task thrown upon it than it can undertake. Thus, a rapid dissolution of corpuscles may take place from various conditions; for instance, there may be an excess of blood after a bloodless amputation, where the blood of a limb before the operation has been driven into the rest of the body; or, again, when the blood from the after-birth has been allowed to flow into the body of a baby. In these cases the liver may be unable to excrete all the pigment and

jaundice will arise. A similar condition will follow any obstruction to the outflow of bile from the liver (gall-stone, inflammation of ducts, &c.) The already secreted bile will in that case pass back into the system through the absorbent lymphatics. In the bile are certain organic salts, taurocholate and glycocholate of sodium. It is probable that these result from the destruction of albumen, perhaps that of the red blood-corpuscles. Of these salts and their rôle in the economy there is much to be learned; they are probably in part reabsorbed from the intestine into the blood.

These functions of the liver commence at an early period of intra-uterine life, the excreted bile accumulating in the intestine, and forming the greenish substance, meconium. After birth the bile may be looked upon not only as an excretion from the body, but as performing in its outward passage through the intestine the part of an aid to digestion and absorption (see BILE, DIGESTION).

But the liver has other and perhaps equally important functions to perform. It is a great storehouse of food material. When the body is well nourished the liver cells store a certain quantity of fat, which they can part with during starvation. In stall-fed animals, beer-drinkers, &c. the liver is loaded with fat, while the liver (*pâté de foie gras*) of the Strasbourg goose is a mass of fat, with hardly any vestige of the original tissue left.

Claude Bernard was the discoverer of one of the greatest functions of the liver. It appears that carbohydrates and proteids absorbed in a soluble form into the blood are, for the most part, seized by the liver and prevented from entering the general circulation. The liver retains them chiefly in the form of glycogen or animal starch, $C_{12}H_{22}O_{11}H_2O$; and after a good meal as much as 5 per cent. of the organ may consist of it alone. This glycogen is then discharged from the liver, probably in the form of a soluble sugar, as the economy is in need of it. We have here a wonderful provision for regulating the food-supply to the tissues, for it would be of obvious disadvantage to them were they inundated with pabulum directly after each meal, and then left without any at all. Many

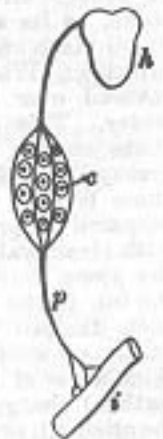


Fig. 2.—Diagram of Liver: i, intestines; p, portal vein breaking up into capillaries among liver cells (c); blood subsequently passes to heart (h).



Fig. 1.—The Liver:

A, right lobe; B, left lobe; a, depression for colon; b, depression for right kidney and capsule; cc, coronary ligament; inferior layer; dd, surface uncovered by peritoneum; e, gall-bladder; ff, fissure for gall-bladder; gg, transverse fissure; h, lobulus quadratus; i, umbilical vein; j, hepatic duct; k, hepatic artery; l, ductus venosus; mm, fissure for ductus

parts of the body, the muscles for instance, are capable of storing glycogen on their own account; but this power is limited, and the great glycogen storehouse is the liver.

We have already seen that there is evidence that proteid substances are broken down in the liver. The greater part of the nitrogen of the proteid is excreted by the kidneys in the form of urea, which substance, as has experimentally been shown, has its primary origin in the liver itself. If carbonate of ammonia be injected through the organ it is converted into urea, which appears in increased quantity in the blood, and is excreted by the kidneys. After a highly nitrogenous diet urea in like manner appears in the blood, the nitrogen having separated from the proteid molecule. In birds and reptiles, where the nitrogen waste of the body is uric acid, not urea, the former substance is also formed by the liver, extirpation of the organ causing a marked diminution in the uric acid formation.

DISEASES OF THE LIVER.—The liver, like other organs of the body, is subject to disorder and disease. It is subject to congestion from exposure to cold, and it is certain to suffer from any prolonged violation of the laws of dietetics. The European living in India who persists in the food habits of a cold climate, although he lives in a warm one, is certain to develop a 'liver.' The beer-drinker acquires a fatty liver, and the dram-drinker an organ in which the cellular elements have greatly diminished, the mass of the organ becoming mere fibrous tissue. The most important, because the commonest, malady connected with disorder of the liver is that known as *biliousness*. The acute form, or 'bilious attack,' has been shortly noticed under Bile (q.v.); but many persons suffer habitually or for long periods from an allied condition. The symptoms are very various; but the most common are dull pain with a feeling of weight in the region of the liver, and pain in the right shoulder, usually worst after meals; a bitter taste in the mouth, with coated, yellowish tongue, dull headache, giddiness; sometimes drowsiness, sometimes sleeplessness; and generally more or less depression of spirits. The condition is most apt to occur in those who take too much or too rich food or drink, with too little exercise. It is probably caused not merely by deficient secretion of bile, but by imperfect performance of the other functions of the liver, especially the disintegration of albuminoid bodies. For the removal of the condition the most important measure is proper regulation of the patient's habits. Great care in diet must be enjoined, particularly as regards alcoholic drinks. Of these malt liquors and sweet or strong wines are the most injurious; but it is generally best to abstain from them altogether. Rich dishes must be avoided, and sugar and meat be taken in moderate amount. Exercise in the open air is very important: riding is the most, walking probably about the least, useful form. With regard to drugs, mercurials (e.g. blue pill) often give great relief; but their habitual use is dangerous. A daily draught in the morning of some saline aperient is generally desirable; and nitro-hydrochloric acid in small doses, with some bitter tonic, is often very useful. Biliousness seldom seriously shortens life, but it often grievously interferes with its enjoyment, and with the power of doing work with any vigour or satisfaction.

Congestion of the liver occurs in at least some cases of biliousness, and in inflammation of the organ; but also in consequence of disease of the heart or lungs causing interference with the return of blood through it. In long-standing cases of this disease the substance of the liver presents a peculiar mottled appearance, whence it is called *nutmeg liver*.—*Gall-stones* (see CALCULUS) and *Jaundice* (q.v.) have already been considered.

Acute inflammation (hepatitis) and *abscess* may occur in the course of other diseases, especially pyæmia; but in their most characteristic form they are much more common in hot countries, and in a large proportion of the cases accompany or follow dysentery. The symptoms are extremely variable; there may be fever, pain, or weight in the liver and right shoulder, and disturbance of digestion; but in some cases all these are absent. If the abscess be in the anterior part of the liver, its presence may be indicated by bulging, or enlargement with alteration of shape of the organ; but if deeply seated no indication of its presence may be found.

Treatment.—In the early stages the disease sometimes seems to be checked by the administration of

large doses of ipecacuanha and the application of poultices or hot fomentations; and even when an abscess is present it may subside spontaneously, or may discharge through lung, stomach, bowels, or skin with a favourable result. Such cases, however, are exceptional; and the introduction of the aspirator and of antiseptic methods has shown that surgical interference in such cases need not be dreaded as it once was. Evacuation and opening of liver abscesses have in fact in recent years saved many lives that would otherwise in all probability have been sacrificed.

Acute yellow atrophy of the liver is a curious and happily rare disease, chiefly affecting young women, in which rapid and intense jaundice, attended by severe nervous symptoms (headache, delirium, coma, &c.), but without fever, almost invariably leads to a fatal issue in a few days. After death the liver is found much diminished in size; and its secreting cells are reduced to a mass of oily debris. The symptoms much resemble those of phosphorus poisoning; but the causes of the disease are as yet obscure.

Cirrhosis of the liver, or interstitial hepatitis (Gr. *kirros*, 'yellowish'), begins as an inflammatory affection, in which lymph (see INFLAMMATION) is effused in the areolar tissue surrounding the branches of the portal vein. The smaller branches become obliterated by the pressure, and, as the lymph subsequently contracts, larger branches of the veins and ducts become strangulated, and the surface of the organ assumes the uneven or bossed appearance known as *hobnailed*. In this affection the liver is probably at first somewhat enlarged, and occasionally remains so, but in general as the contraction of the effusion goes on it at length becomes considerably smaller than the natural size. The ordinary cause of this disease is spirit-drinking, and it is popularly known as the *gin-drinker's liver*. The obstruction to the portal circulation occasions the effusion of serum into the peritoneal cavity; and this effusion often goes on so rapidly as soon to force up the diaphragm and impede respiration. The lower extremities may become anasarctous, but the arms and face are never affected. The portal obstruction often also gives rise to hemorrhage from the bowels or stomach. In a fully developed case of cirrhosis the liver is so altered in structure that palliative treatment is all that can be attempted. This must be directed to the relief of the dropsy, and, if medicines fail to remove or diminish it, temporary relief may be obtained by tapping; but the disease is a very hopeless one.

Amongst the other affections of this organ are the *fatty liver*. The liver in this case is much enlarged, of a pale colour, and rounded at the edges; the disease is most commonly found associated with phthisis and in cases of general obesity. Closely allied to this is the *lardaceous* or *waxy liver* (see WAXY DISEASE). Tubercle, syphilitic disease, and different forms of cancer, generally secondary to cancer elsewhere, are not unfrequently found in this organ. It is also much the most frequent seat of Hydatids (q.v.).

Lixivation (Lat. *lix*, 'ashes'), a term employed in chemistry to denote the process of washing or steeping certain substances in a fluid, for the purpose of dissolving a portion of their ingredients, and so separating them from the insoluble residue. Thus, wood-ash is lixiviated with water to dissolve out the carbonates of soda and potash from the insoluble parts. The solution thus obtained is called a *lixivium*, or *ley*.

Lock, an arrangement for fastening doors, drawers, &c., and requiring a key or other similar contrivance to open it. The early Egyptians used locks of rude construction, generally made of wood; and locks and keys of bronze and iron have been found in large numbers in Pompeii and Herculaneum. Fig. 1 represents the ancient Egyptian lock in section: *a* is the case, fastened to the door; *b*, the bolt; in the upper part of the case are three openings, *c*, each containing a pin with a head to prevent its falling too far down. When the bolt is pushed home towards *b*, the pins fall into the corresponding three holes, *d*, preventing its being withdrawn. The key is a piece of wood, *e*, which

is pushed into the opening, *f*, in the bolt, and by means of its three pins the pins in the case are pushed up while the bolt is withdrawn. An exactly similar lock is still used in the Faroe Islands, and one very like it in St Kilda. The Chinese for many hundred years have had a much superior wooden lock with tumblers.

During the 15th, 16th, and 17th centuries very ingenious and complicated locks, richly ornamented with hammered iron-work, were made, especially in Germany, and in every collection may be seen more or less fine specimens. These, however, were necessarily very expensive, and could only be used by the wealthy, and the lock in ordinary use up to the beginning of the 19th century was the common



Fig. 2.

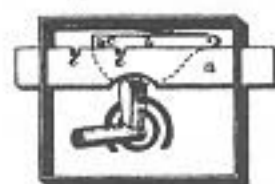


Fig. 3.

spring-lock shown in fig. 2, and which is still used for ordinary purposes. The bolt, *a*, passes through an opening in each side of the case, and is held in position by the two notches, *bb'*, which are pressed against the bottom of the opening, *c*, by the spring, *d*, as the bolt is locked or unlocked. The key, acting in the semicircular notch, *e*, in the bolt, pushes it either to one side or the other as required; the fig. represents the bolt midway between open and locked. Certain notches in the key fitting into corresponding wards, *f*, fastened to the plate of the lock, are supposed to prevent any other instrument but its own key from opening the lock. The first improvement on this was the common tumbler-lock (fig. 3), which represents the simplest form of it: *a* is the bolt; *b*, the tumbler, with a projection, *c*, which is pressed by the spring, *d*, into the notches, *e, e'*, according as the lock is open or shut. The key, by the one movement, raises the tumbler and moves the bolt.

Barron's lock, patented in 1778, was a development of the tumbler principle. By putting the notches in the centre of the bolt instead of on the top edge, the pin in the tumbler had to be lifted to an exact height to pass the bolt, rendering it much more difficult to pick. Barron subsequently added a second tumbler which had also to be passed by the bolt. Barron's form of construction is still in use, and it may be considered the parent of the modern many-tumbler or lever lock, of which Moses Birl's (1780) was the first.

The lock patented by Joseph Bramah in 1788, and still one of the recognised best locks for certain purposes, is of a different construction. An inner barrel turning inside a fixed cylinder has a central pin on which the key works. The key (fig. 4) is a simple pipe with generally four slits, *a, a, a*, and a pin, *b*; when it is inserted and pressed down, the slits press on corresponding slides working in the inner barrel, till, arriving at a certain point, the barrel is released and can be turned round by the pin, *b*; another pin on the barrel moves the bolt. A spiral spring on the central pin keeps the slides in their original position till pressed down by the key. The varying depths of the slits in the key agree with the distance which the different slides have to be pressed down; and, as no two locks are alike in this respect, each key can only open its own lock. So much confidence had the Messrs Bramah in this lock that during the Great Exhibition of 1851 they offered a prize of two hundred guineas to any one picking it, which prize was gained by Mr Hobbs, an American, who occupied fourteen days in devising and making tools, and fifty-one hours actually at work on the lock.

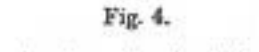


Fig. 4.

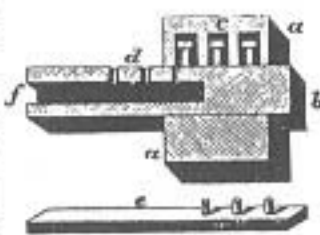


Fig. 1.

Chubb's lock, originally patented in 1818, is a further development of the many-tumbler principle. It is shown in fig. 5, which represents it unlocked, and with the inner plate removed the better to show the movement: *a* is the bolt; *b*, the tumblers, six in this instance, which move independently on the common pin, *c*, each having one of the six springs, *d*, to keep it in position. The stump, *e*, riveted to the bolt, must pass through the gate, *f*, in all the tumblers before the bolt can be shot. As this gate is in a different

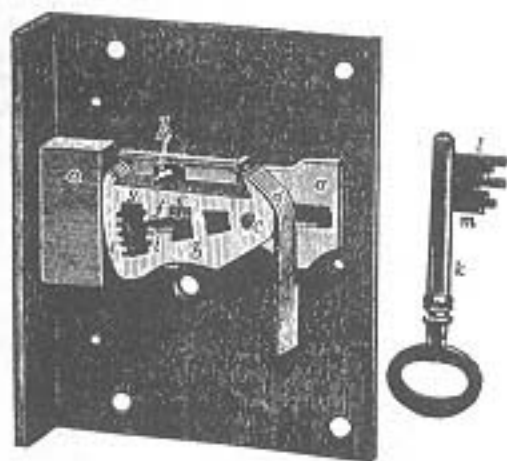


Fig. 5.

position in every tumbler, they must be raised to correspondingly different heights before they coincide for the stump to pass. For this purpose the key, *k*, has different steps so arranged that, when it is turned in the lock, each step raises its own tumbler to the proper height, and the step nearest the end of the key, *i*, shoots the bolt; the stump passing through the coinciding gatings and slipping into the space, *g*, as the tumblers, released by the key, resume their original position. In opening the lock the reverse of this movement takes place. A pin, *d*, fixed on the backmost tumbler and reaching over the tops of the others is called the detector. Should any false key be tried in the lock when locked, or any other means used which should raise either of the tumblers too high, an ingenious arrangement fixes it so that the lock is obstructed and cannot be opened, even with its own key, till the fixed tumbler is released. This is done by making an extra forward movement of the key, when the tumbler will resume its normal position. This detector movement is intended as a precaution against burglars, and also to record any attempt to pick the lock. False notches, *i*, *i*, are made in the tumblers to defeat attempts to pick the lock by feeling for the different gatings by backward pressure of the bolt applied by ingenious instruments—a method, difficult as it may seem, which has been successfully used against all tumbler-locks, unless specially safeguarded. A movable circular curtain attached to the keyhole in the inner plate is moved by the aftermost step of the key, *m*, as it is turned round. This prevents an inspection of the tumblers for picking purposes by means of a reflector introduced into the keyhole, while they are moved by any instrument, as nothing can be turned round in the lock without also turning the curtain.

Hobbs's protector lock has a series of tumblers as in Bird's and Chubb's locks, but, in addition, has what is termed a *protector*, shown in fig. 6. It consists of a shaped lever, *a*, *b*, working on the pin, *c*, which is riveted into the bolt, *A*, and it is kept in position by the friction spring, *e*. The stump, *b*, is fixed to the protector, and, passing through a hole in the bolt, acts on the tumblers (not seen in the fig.) at the other side of the bolt. This arrangement entirely prevents feeling for the gatings of the tumblers by pressing back the bolt. If any attempt is made to push back the bolt when locked, it only moves the protector enough to bring down the long arm, *a*, in front of the pin, *d* (fixed in the back plate of the lock), as shown in the fig. This prevents any further movement of the bolt till the protector is set free by a slight turn of the proper key. This lock, when in combination with another ingenious arrangement called the *revolving nozzle*, which prevents tampering with false keys, has successfully resisted all attempts to pick it.

Lord Grimthorpe (formerly Beckett-Denison) invented a modification of the tumbler-lock which locks with a handle, only requiring a small key to open it. The keyhole is so narrow that no instrument strong enough to injure the lock can be introduced. It has other advantages, and its inventor claims that it is unpickable. It has not been patented. He is also the inventor of a dust excluder for the key-holes of locks, operated by a spiral spring.

Many other varieties of the tumbler or lever

lock have been invented which we have not space to describe.

Combination locks are sometimes used for burglar-proof safes. In these locks the tumblers are represented by wheels, generally four in number, which can be turned independently in connection with an index on the outside of the safe. The lock can only be opened by making certain movements of the handle on the index, which cause the gatings in the wheels to coincide. The combination of numbers on the index with the different wheels can be altered at pleasure, and, of course, the lock can only be opened by those knowing this combination. The weak point of this lock is that the combination may be forgotten. The Yale time-lock is an improvement, by Mr Yale of Philadelphia, on the time-lock invented by Rutherford of Jedburgh, Scotland, in 1831. A watch in combination with the lock may be set so that the lock can only be opened at a particular hour even by the owner.

Changeable-key locks were first introduced into England by Mr Hobbs, who brought Day and Newell's *paraoptical* lock to London in 1851. After many improvements, Mr Hobbs perfected this lock in 1862, and in 1865 the firm of Hobbs, Hart, & Co. introduced a simpler and cheaper form of it. By an ingenious modification of the tumblers, which we have not space to describe, the lock may be locked by any one of a great number of keys, but can only be opened by means of the one which locked it. Some of these locks afford a possible choice from about 60,000,000 keys, any one of which will lock it, and which must be used to open it again. To avoid the necessity of having a number of keys, different webs are supplied which fit on the key-pipe to form the key. The webs may be kept in the safe, one taken out at random to lock up with; the web removed from the key carried away in the waistcoat pocket, and the key hung up anywhere, useless till the web is brought back.

In the ordinary safe locks the bolts are necessarily on a large scale, and, to prevent the carrying about of a key of corresponding magnitude, the bolts are usually shut by means of a handle, and a small lock with a small key locks one of them and fastens them all.

Latch-locks used on street doors which shut of themselves, and are opened by means of a handle

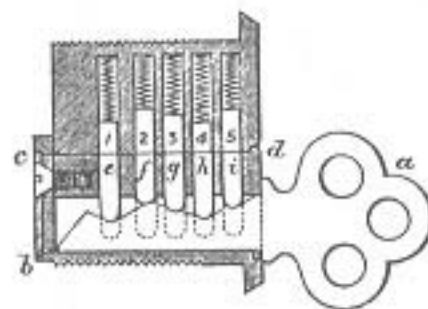


Fig. 7.

d is a movable barrel turning inside the lock; 1, 2, 3, 4, 5 are five pins pressed down by spiral springs working in holes in the fixed part; *e*, *f*, *g*, *h*, *i* are five corresponding pins moving in holes in the inside barrel; they are of irregular lengths, and when the key is out, *e*, *f*, *g*, *h*, *i* drop down, as shown by the dotted lines, allowing 1, 2, 3, 4, 5 to drop into the holes in the barrel, fixing the lock. As the key, which has indentations exactly corresponding with the varying lengths of *e*, *f*, *g*, *h*, *i*, is pushed in, it raises those pins till they and 1, 2, 3, 4, 5 coincide at the junction of the barrel and the fixed part of the lock. The barrel may then be turned and a pin on it shoots the bolt, not shown in the fig. The key is a thin piece of tempered steel weighing only a small fraction of an ounce, and the keyhole correspondingly narrow.

Locks made for various purposes, such as doors, drawers, writing-desks, portfolios, cupboards, &c., however differing in arrangement, are all constructed on the same principle. The *padlock*, in which the lock is a separate arrangement, is precisely similar to other locks except in shape. It has also a movable bow which is hooked into a staple or other fastening and then locked.

Locks for drawers, cupboards, and the like, which only require to be opened on one side, are generally made with a central pin on which the key, with a pipe, works; but in locks which must be opened from both sides this arrangement is impossible, and the key is solid, working through

a hole in the lock. It must, however, be symmetrical, so as to exactly reach the turning place of the lock from either side. Locks which are mortised into the thickness of the door are called *mortise* locks.

Many ingenious automatic latches have been invented for cabinets and the like, which shut of themselves when the door is closed, and can be pulled open without a key or turning a handle; they are used when security is not required, only a means of keeping the door closed.

Logarithms, a series of numbers having a certain relation to the series of natural numbers, by means of which many arithmetical operations are made comparatively easy. The nature of the relation will be understood by considering two simple series such as the following, one proceeding from unity in geometrical progression, the other from 0 in arithmetical progression:

Geom. series, 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, &c.

Arith. series, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, &c.

Here the ratio of the geometrical series is 2, and any term in the arithmetical series expresses how often 2 has been multiplied into 1 to produce the corresponding term of the geometrical series; thus, in proceeding from 1 to 32, there have been 5 steps, or multiplications by the ratio 2; in other words, the ratio of 32 to 1 is compounded five times of the ratio of 2 to 1. It was this conception of the relation that led to giving the name of *Logarithms* to the terms of the arithmetical series, the word *logarithm* (Gr. *logon arithmos*) meaning 'the number of the ratios.' As to the use that may be made of such series, it will be observed that the sum of any two logarithms (as we shall now call the terms of the lower series) is the logarithm of their product—e.g. 9 (= 3 + 6) is the logarithm of 512 (= 8 × 64). Similarly, the difference of any two logarithms is the logarithm of the quotient of the numbers; a multiple of any logarithm is the logarithm of the corresponding number raised to the power of the multiple—e.g. 8 (= 4 × 2) is the logarithm of 256 (= 16²), and a submultiple of a logarithm is the logarithm of the corresponding root of its number. In this way, with complete tables of numbers, and their corresponding logarithms, addition is made to take the place of multiplication, subtraction of division, multiplication of involution, and division of evolution.

In order to make the series above given of practical use, it would be necessary to complete them by interpolating a set of means between the several terms, as will be explained below. We have chosen 2 as the fundamental ratio, or base, as being most convenient for illustration; but any other number (integral or fractional) might be taken; and every different base, or *radix*, gives a different system of logarithms. The system now in use has 10 for its base; in other words, 10 is the number whose logarithm is 1.

The idea of making use of series in this way would seem to have been known to Archimedes and Euclid, without, however, resulting in any practical scheme; but by the end of the 16th century trigonometrical operations had become so complicated that the wits of several mathematicians were at work to devise means of shortening them. The real invention of logarithms is now universally ascribed to John Napier (q.v.), Baron of Merchiston, who in 1614 printed his *Canon Mirabilis Logarithmorum*. His tables only give logarithms of sines, cosines, and the other functions of angles; they also labour under the three defects of being sometimes + and sometimes -, of decreasing as the corresponding natural numbers increase, and of having for their *radix* (the number of which the logarithm is 1) the number which is the sum of

$1 + 1 + \frac{1}{1 \cdot 2} + \frac{1}{1 \cdot 2 \cdot 3} + \dots$, &c. In many calculations,

however, the latter is an advantage rather than a defect. These defects were, however, soon remedied: John Speidell in 1619 amended the tables in such a manner that the logarithms became all positive, and increased along with their corresponding natural numbers. He also, in the sixth edition of his work (1624), constructed a table of Napier's logarithms for the integer numbers, 1, 2, 3, &c., up to 1000, with their differences and arithmetical complements, besides other improvements. Speidell's tables are now known as *Hyperbolic logarithms*. But the greatest improvement was made in 1615, by Professor Henry Briggs (q.v.), of London, who substituted for Napier's inconvenient 'radix' the number 10, and succeeded before his death in cal-

culating the logarithms of 30,000 natural numbers to the new radix. Briggs's exertions were ably seconded; and before 1628 the logarithms of all the natural numbers up to 100,000 had been computed. Computers have since chiefly occupied themselves rather in repeatedly revising the tables already calculated than in extending them.

Construction of Tables.—The following is the simplest method of constructing a table of logarithms on Briggs's system. The log. of 10 = 1; the log. of 100 (which is twice compounded of 10) = 2; the log. of 1000 = 3, &c.; and the logarithms of all powers of 10 can be found in the same manner. The intermediate logarithms are found by continually computing geometric means between two numbers, one greater and the other less than the number required. Thus, to find the log. of 5, take the geometric mean between 1 and 10, or 3.162..., the corresponding arithmetic mean (the log. of 1 being 0, and that of 10 being 1) being 0.5; the geometric mean between 3.162... and 10, or 5.623..., corresponds to the arithmetic mean between 0.5 and 1 or 0.75; the geometric mean between 3.162... and 5.623..., or 4.216..., has its logarithm = $\frac{1}{2}(0.75 + 0.5)$ or 0.625; this operation is continued till the result is obtained to the necessary degree of accuracy. In this example the twenty-first result gives the geometric mean = 5.000,003, and the corresponding arithmetic mean = 0.698,970, which is in ordinary calculations used as the logarithm of 5. Since division of numbers corresponds to subtraction of logarithms, and since $2 = \frac{1}{5}$, the log. of 2 = log. 10 - log. 5 = 1 - 0.698970 = 0.301030. The logarithms of all prime numbers are found in the same way as that of 5; those of composite numbers are obtained by the addition of the logarithms of their factors; thus the log. of 6 = log. 2 + log. 3 = 0.301030 + 0.477121 = 0.778151. This method, though simple in principle, involves an enormous amount of calculation; and the following method, which depends on the modern algebraic analysis, is much to be preferred. According to this method, logarithms are considered as indices or powers of the radix; thus, $10^0 = 1$, $10^{0.301030} = 2$, $10^{0.477121} = 3$, $10^1 = 100$, &c.; and the laws of logarithms then become the same as those of indices. Let r represent the radix, y the natural number, x its logarithm; then $y = r^x$, or, putting $1 + a$ for r , $y = (1 + a)^x$; and it is shown by the binomial and exponential theorems (see the ordinary works on Algebra) that $y = 1 + px + \frac{p^2x^2}{1.2} + \frac{p^3x^3}{1.2.3} + \&c.$, where $p = r - 1 - \frac{1}{2}(r - 1)^2 + \frac{1}{6}(r - 1)^3 - \&c.$, the former equation expressing a number as the sum of different multiples of its logarithm and the radix. If $1/p$ be substituted for x , then $y = 1 + 1 + \frac{1}{1.2} + \frac{1}{1.2.3} + \&c. = 2.71828182...$ which, as before mentioned, is Napier's radix, and is generally called e . Hence $r = e^p$, or p is the logarithm of r to the base or radix e . Then, referring to the above-mentioned value of p , we have log. r (i.e. log. of r to the base e) = $r - 1 - \frac{1}{2}(r - 1)^2 + \frac{1}{6}(r - 1)^3 - \&c.$, or, as before, putting $1 + a$ for r , log. $(1 + a) = a - \frac{a^2}{2} + \frac{a^3}{3} - \&c.$; a series from which log. $(1 + a)$ cannot be found, unless a be a proper fraction. But if we put $-a$ for a , log. $(1 - a) = -a - \frac{a^2}{2} - \frac{a^3}{3} - \&c.$; and, subtracting this expression from the former, log. $(1 + a) - \log. (1 - a)$ or log. $\frac{1 + a}{1 - a} = 2(a + \frac{a^3}{3} + \frac{a^5}{5} + \&c.)$; and, for the sake of convenience, putting $(u + 1)/u$ for $(1 + a)/(1 - a)$, in which case $a = 1/(2u + 1)$, we finally obtain log. $(u + 1)/u = 2\{1/(2u + 1) + 1/3(2u + 1)^3 + 1/5(2u + 1)^5 + \&c.\}$, or log. $(u + 1) = \log. u + 2\{1/(2u + 1) + 1/3(2u + 1)^3 + 1/5(2u + 1)^5 + \&c.\}$. If 1 be put for u in this formula, the Napierian logarithm of 2 is at once obtained to any degree of accuracy required; if 2 be put for u , the Napierian logarithm of 3 can be calculated, &c. Now, as logarithms of any system have always the same ratio to one another as the corresponding logarithms of any other system, no matter what its base, if a number can be found, which, when multiplied into the logarithm of a certain number to one base, gives the logarithm of the same number to another base, this multiplier will, when multiplied into any logarithm to the first base, produce the corresponding logarithm to the other base. The multiplier is called the modulus, and, for the conversion of Napierian into common or Briggs's logarithms, is equal to 0.4342944...; so that, to find the common logarithm of any number, first find the Napierian logarithm, and multiply it by 0.4342944...

As in Briggs's system the logarithm of 10 is 1, and that of 100 is 2, it follows that all numbers

between 10 and 100 have for their logarithms unity

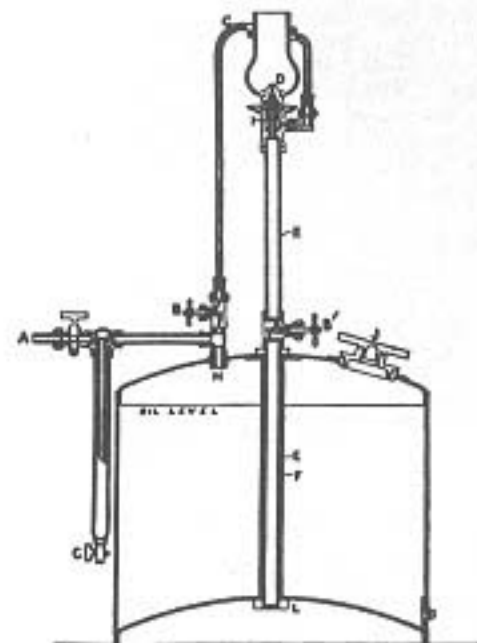
+ a proper fraction; in other words, the integer portion of the logarithms of all numbers of two figures is unity; similarly, the integer portion of the logarithms of numbers between 100 and 1000 is 2, and, in general, the integer portion of the logarithm of any number expresses a number less by unity than the number of figures in that number. This integer is called the *characteristic*, the decimal portion being the *mantissa*.

As the logarithm of 1 = 0, the logarithms of quantities less than unity would naturally be negative; thus, the logarithm of $\frac{1}{2}$ would be -0.30103. But, for convenience in working, the mantissa is kept always positive, and the negative sign only affects the characteristic; the logarithm of $\frac{1}{2}$ or 0.5 would thus be $\bar{1}.69897$, the characteristic in this and similar cases expressing, when the fraction is reduced to a decimal, the number of places the first figure is removed from the decimal point; thus, the logarithm of 0.0005 is $\bar{4}.69897$.

Logwood, the dark red heart-wood of *Hæmatoxylon campechianum*, a tree of the natural order Leguminosæ. This tree, which is a native of Mexico and Central America, and has been naturalised in some of the West India Islands, grows to a height of 20 to 50 feet. The tree is generally felled when about ten years old, and the sapwood being worthless is hewed off with the bark. The heart-wood is slightly heavier than water, hard, and close-grained. It has a slight smell resembling that of violets, is astringent, and has a sweetish taste. The source of the colouring properties of logwood is a crystalline substance called hæmatoxylin, $C_{16}H_{14}O_6$, itself colourless when pure, but in an alkaline solution in the presence of oxygen (air) it becomes converted into hæmatein, $C_{16}H_{12}O_4$, which is of a purple-red colour. For dyers' use ground or rasped logwood is moistened and made up into heaps or layers in a moderately warm place, where, turned over at intervals, it undergoes fermentation, ammonia being one of the products of the process. The result is that hæmatoxylin is first formed and afterwards hæmatein, crystals of which, of a reddish-brown colour and greenish lustre, coat the particles of wood. The hæmatein or colouring matter is easily dissolved by placing the rasped wood, so treated, in hot water. Extracts of logwood also are made for dyeing purposes. Logwood, although itself dark red, does not produce red colours either alone or with any of the ordinary mordants in use for it. Shades of purple, blue, lavender, drab, and gray are obtained from it with suitable mordants, but none of these are permanent. Its most important application is for dyeing black colours (see DYEING). It is also used in the manufacture of writing ink (q.v.). As a medicine logwood is sometimes given in cases of chronic diarrhoea.

Loofah, EGYPTIAN. Under this name the fibrous portion of the fruit of one or two species of *Luffa* (nat. ord. Cucurbitaceæ) is sold in England for use as a bath-sponge or flesh-rubber. There are about ten species of the genus known, but the 'towel gourd,' as this bath-sponge is sometimes called, appears to be obtained chiefly from *L. ægyptiaca*. In the West Indies the fruit of *L. acutangula* yields a similar network of fibres, and it is there used as a sponge or dishcloth. The fibrous portion of these gourds is also worked up into baskets and small ornamental articles.

Lucigen, one of the most powerful artificial lamps, and specially well adapted for lighting large spaces, whether open or covered. The light, which is produced by burning creasote-oil, is brilliant and diffused, and does not cast black shadows like the electric light, as the flame gives a broad glow resembling very much the effect of the sun. The construction of the lamp is exceedingly simple. The tank or oil-reservoir is a plain circular drum, to the top of which the burner is fixed. The burner-tube, E, extends to the bottom of the drum, passing through an outer tube F, which is pierced with holes through which the oil is strained, and passes down into the small well, L, in the bottom of the tank. The compressed air enters the drum at H, and forces the oil up the tube, E, to the oil-cone I. The heated air from the coil, C, enters the annular space between the oil-cone and burner, where the air and oil become amalgamated and escape in the form of a spray or vapour which is immediately inflammable. There are various forms of the



Section of a Lucigen Lamp:

A, air supply; B, stopcock for controlling supply of air to burner; D, stopcock for controlling oil-feed; C, coil for heating air; E, burner; F, burner-tube; G, strainer-tube; H, drip-cock for condensed moisture; I, air to drum; J, oil-cone; K, for oil supply; L, oil well.

Lucigen, which was first used in 1885; but for a universal lamp the vertical type worked by compressed air may be taken as the best, which, with about 18 lb. pressure at the burner, gives the most regular and effective light.

Lumbago is a rheumatic affection of the muscles or fibrous tissues in the lumbar region, or small of the back. It is often first recognised by the occurrence of a sharp stabbing pain in the loins upon attempting to rise from the recumbent or sitting position. It is sometimes so severe as to confine the patient to bed and in one position, from which he cannot move without intense suffering; but in milder cases he can walk, although stiffly and with pain, and usually with the body bent more or less forward. It may be distinguished from inflammation of the kidneys by the absence of the peculiar direction of the pain towards the groin, as also by the absence of the nausea and vomiting and other constitutional symptoms which usually accompany the disease of the kidney.

The causes of lumbago are the same as those of sub-acute rheumatism generally. The complaint may arise from partial exposure to cold, especially when the body is heated, and violent straining will sometimes induce it. In persons with a strong constitutional tendency to rheumatism the slightest exciting cause will bring on an attack of lumbago.

The treatment must vary with the intensity of the affection. In most cases a warm bath at bedtime, followed by ten grains of Dover's powder, or full doses of alkaline remedies, as citrate of potassium, will speedily remove it; and, as local remedies, a mustard poultice, a mixture of chloroform and soap-liniment, or the application of the heated hammer made for the purpose will be found serviceable. (See also the treatment for RHEUMATISM.) The disorder has been known to completely disappear after one application of the hammer, which should be heated in a spirit-lamp to somewhere about 200°, and then be rapidly brought in contact with points of the skin over the painful parts at intervals of about half an inch. Each application leaves a red spot, but blisters seldom occur if the operation is properly performed. The application of a hot iron, used just as in ironing clothes, with two or three folds of blanket between it and the skin, frequently gives great relief.

Luminous Paint, a phosphorescent powder, such as sulphide or oxysulphide of calcium, ground up with a colourless varnish or other medium, and used as a paint. Even after daylight is over the Phosphorescence (q.v.) goes on, and the object painted remains visible in the dark.

Lute (Lat. *lutum*, 'clay'), in Chemistry, denotes a substance employed for effectually closing the joints of apparatus, so as to prevent the escape of vapour or gases, or for coating glass vessels so as to render them more capable of sustaining a high temperature, or for repairing fractures.

Lye, a term sometimes used to denote all solutions of salts, but more generally appropriated to solutions of the fixed alkalis, potash and soda, in water. The solutions of caustic potash and soda are called caustic lyes; those of their carbonates, mild lyes. The fluid which remains after a substance has been separated from its solution by crystallisation is called the *mother lye*.

Lynch Law, the summary trial and punishment of offenders by private and unauthorised persons. This mode of administering justice has been necessarily employed in countries newly settled, where the power of the civil government is not yet sufficiently established. The frequency with which it has been resorted to in the southern and western states of the American Union, however, as a punishment for serious criminal offences, is to be referred rather to a doubt on the part of the mob as to the adequacy of the ordinary legal machinery. In the six years 1884-89 the number of murders in the United States was reported as 14,770, of legal executions 558, and of lynchings 975. Of course, the infliction of any minor punishment without legal trial constitutes lynch law (see *VIGILANCE SOCIETIES*), but the simple term 'lynching' usually implies capital punishment.—The phrase has been variously traced to a Virginia soldier and to a Virginia farmer of that name, to one Lynch who was sent out from England about 1687 to suppress piracy, and to a mayor of Galway (q.v.) in Ireland; while yet another tradition refers it to Lynch Creek, in North Carolina, where the forms of a court-martial and execution were gone through over the lifeless body of a Tory, who had already been precipitately hanged to prevent a rescue.

Machine Gun may be defined as a weapon mechanically loaded with fixed ammunition from a hopper or frame, so as to fire a succession of projectiles from a rest or carriage, in contradistinction to hand weapons, such as Repeating (or magazine) Rifles (q.v.) and Revolvers (q.v.).

Machine guns may be divided into two classes—the mitrailleuse, which discharges a stream of bullets not much exceeding 1 inch in diameter, and the revolving cannon or quick-firing gun, which throws an explosive shell of several pounds weight. The first class includes rifle-calibre guns for use against troops, and naval guns firing steel shot capable of piercing the sides of a torpedo boat. The second is an improvement on ordinary Cannon (q.v.), though perhaps sometimes considered less suited to all the contingencies of a campaign, in consequence of the comparatively delicate nature of the mechanism employed.

A breech-loading Requa battery (an improved Ribaudequin or organ gun), consisting of thirty-one rifle-barrels arranged in three parallel rows, loaded simultaneously by means of a set of chambers, and fired at once by a single cap, has been in the Rotunda Museum at Woolwich since before 1830. A Requa battery was used at the siege of Charleston in 1863, and seems to contain the germ of such inventions as the Gardner and Nordenfolt machine guns, while those like the Gatling and the Hotchkiss revolving cannon seem traceable to the early patterns of revolver-pistol. The first of such weapons to be used in field operations was the Gatling, which was tested in the American civil war, and exhibited in the Paris Exhibition of 1867. This weapon (fig. 1) usually has ten barrels and ten locks, revolved round a fixed axis by means of a handle or crank. In addition to revolving with the barrels, each lock is at the same time gradually pushed forward, so as to carry the cartridge into the barrel, close the breech, and fire the charge as soon as the barrel comes under the sights. It then commences to move backwards, drawing with it the empty cartridge-case, so that, when one revolution of the barrels is complete, the open breech is brought under the drum from which a second cartridge falls into it. Thus, when the ten-barrelled gun is in action, there are always five cartridges going through the loading process and five others being gradually extracted; and this goes on as long as the gun is fed with cartridges, which may be done either by hand, or, as is more usual, by means of a drum fixed above the barrels, as shown in fig. 1. This type of machine gun cannot fire a volley, but the rapidity of its fire is limited only by the movement of the handle. It can also be worked with a slight swaying action, when firing rapidly, so as to spread the bullets over

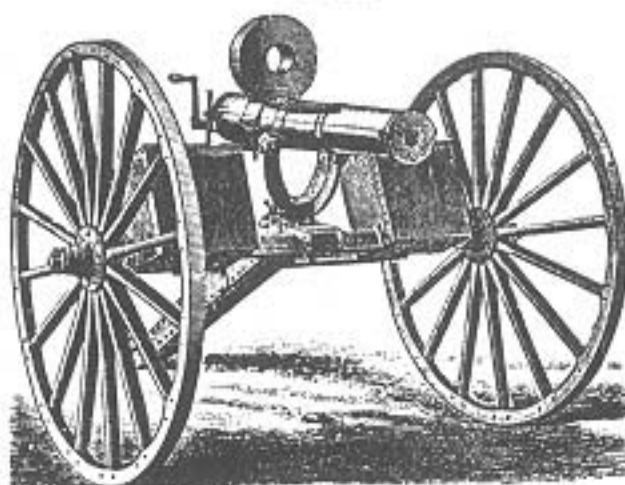


Fig. 1.

Medium size Gatling, mounted on Field Carriage.

a certain amount of lateral space, like water from a fire-hose, and give much the same effect as a volley. The weapons first used fired one hundred bullets each minute, but improved mechanism enables the newer types to fire ten times that number, and to give good results at ranges of 3000 yards. The barrels are of various calibres up to 12 inches; and larger sizes could be made. A few Gatling guns were used in the Franco-German war of 1870, the Russo-Turkish war of 1877-78, the Chiloeno-Peruvian war of 1877, and the British campaigns in Ashantee, Zululand, Egypt, &c.

The Montigny mitrailleuse, adopted by the French army, and used by them in large numbers during the campaign of 1870, consists of thirty-seven rifle-barrels permanently enclosed in an iron cylinder. These are all loaded simultaneously at the breech by means of a metal frame, in which the cartridges are carried, and can be discharged independently or all at once by the action of a crank-handle. Reloading takes five seconds, and ten discharges can be fired per minute. The bullets have no lateral spread, and the effective range is not much over 1000 yards. Numbers of these weapons were secretly manufactured in France previous to 1870, and, on the outbreak of war in that year, were issued to the artillery in place of their field-guns, without any instruction having been given to the men in working them. Formed into batteries of ten pieces, they were expected to beat off both artillery and infantry; but the concentrated shell fire of the

former destroyed them at long ranges, and the rapid movements of the latter often enabled them to capture the mitrailleuses without serious loss. The failure of this weapon brought all machine guns into disfavour; but when protected from artillery fire in savage warfare, their great value for certain purposes, such as flanking the ditches of fortresses, defending defiles, bridges, &c., and naval operations, has since been fully recognised, and very many improved types have appeared.

The Nordenfolt-Palmcrantz system (fig. 2) is particularly useful in the tops of ships. The 1-inch calibre gun, firing steel bullets, is capable of piercing the sides and boilers of torpedo boats at 300 yards. It consists usually of four or more horizontally arranged barrels, and the firing handle on being moved forward and backwards discharges them all, if moved rapidly, in a succession of volleys, if slowly, in a succession of single shots. The number of aimed shots per minute fired at sea varies from one hundred with the 1-inch to ten with the 3-inch gun.

Fig. 3 shows another form of rifle-calibre machine

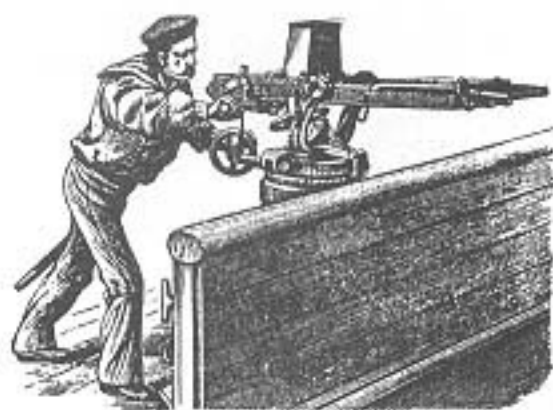


Fig. 2.

Nordenfolt-Palmcrantz Gun, inside Bulwark Mounting.

gun designed by Captain Gardner, late U.S.A., for use with a field army. The operations of loading, firing, and withdrawing the empty cartridge-cases are performed automatically by the breech mechanism, worked by a crank-handle. The car-

tridges are fed in from an upright frame or carrier.

The Maxim automatic machine gun has a single barrel surrounded by an outer case, the space between being filled with water to prevent heating. The breech end of the gun recoils after discharge (the first cartridge being fed in and fired by hand), causing the arm B (fig. 4) to strike the fixed point C, thus imparting to the crank-shaft E a rapidly accelerated rotation, and making the crank-handle F strike the buffer-spring D, which brings it to a state of rest. The rotation of the crank-shaft E also rotates the fusee (shown dotted round E) attached to the chain, and thereby winds it up, so that, when the crank-handle F rests on the buffer D, the spiral spring (dotted) is not only extended 1 inch (due to the recoil), but further elongated by the winding up of the chain on the fusee. After

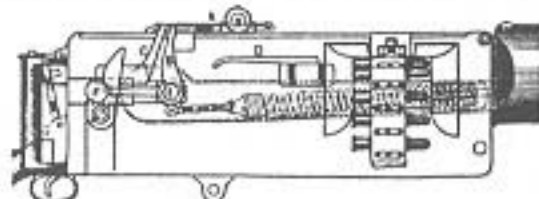


Fig. 4.—Breech Mechanism of Maxim Gun.

the crank-handle F has been brought to rest against the buffer D, the action of the spring is first to pull back the recoiling portion into the firing position, and then to unwind the chain from the fusee, thus rotating the crank-shaft back into its original position. The cartridges are carried on a broad linen belt, to which fresh lengths can be attached, and which is carried round by the mechanism. The accelerated motion of the crank draws back the lock sufficiently to allow the old cartridge to drop out, while the spiral spring causes the lock to come forward quicker than the recoiling portion of the barrel, so that at the same instant as the barrel resumes the firing position the lock closes the breech with a new cartridge and fires it, the recoil setting up the same action again. The gun may be arranged for firing single shots by hand on pressing a button, or to continue firing shots at any required interval of time. As many as 620 rounds per minute have been fired from this gun, and accurate shooting obtained up to 3000 yards. Fig. 5 shows a rifle-calibre Maxim gun, which, with its tripod, only weighs 70 lb. A 3-pounder gun has also been designed on the same principle. All the mechanism is carefully covered in to protect it from grit and dirt, but it can easily be taken to pieces and cleaned.

The Hotchkiss revolving cannon is similar to the Gatling gun, inasmuch as it consists of five barrels revolving round a central axis, but there is only one lock for all five, instead of one for each barrel, and the rotatory motion of the barrels is intermittent instead of continuous. Each turn of the crank-handle loads one barrel and fires another, while an empty cartridge-case is being extracted from a third. The mechanism is in few parts, which are large, strong, and serviceable, with only one spring, and that a large flat one. The breech-piece is solid. The calibres of the revolving cannon vary from 1.5 inch to 2 inches, but the same inventor has made a 6-pounder quick-firing single-barrelled field-gun.

The projectile is either a steel shot for naval purposes or an explosive shell. As many as eighty



Fig. 3.—Five-barrelled Gardner Gun on Tripod Stand.



Fig. 5.—Rifle-calibre Maxim Gun.

rounds per minute have been fired from the revolving cannon, the cartridges being fed in from a hopper-frame, and good results obtained at a range of 5460 yards.

By an order of 1888, a detachment with two machine guns was made part of the war establishment of every brigade of infantry or cavalry in the British army. Each infantry detachment consists of an officer, two non-commissioned officers, and nine men, and is accompanied by a forage-cart and ammunition-cart carrying 6640 rounds for the guns, 1500 more being on each gun-carriage. Two men are sufficient to work each gun, the remainder are drivers and a servant. In the cavalry detachment there are fifteen men, of whom two are servants, seven drivers, and six for working the guns and to act as horse-holders. The ammunition-wagon carries 13,340 rounds of rifle-calibre cartridges.

The mitrailleuse form of machine gun thus takes a definite place in the armament of European troops, not as a substitute for field artillery, against which, if unprotected by cover, it can never stand, but as an auxiliary to infantry and to cavalry acting independently, in positions where rifle-fire is most efficacious. It will also be useful for long range rifle-fire, and perhaps in lieu of an infantry escort to guns when moving rapidly to the front, besides those purposes which have already been alluded to. The shell-firing machine gun and the quick-firing gun, on the other hand, will perhaps supersede the ordinary artillery pieces of similar calibre, which, by not checking or utilising the recoil, entail greater strain upon the carriage, require more men to work them, and take longer to lay after each round.

Magnesium (sym. Mg, equiv. 24) is a metal which is very widely distributed over the globe. It is present in many minerals—e.g. dolomite—a carbonate of lime and magnesia; asbestos—a silicate of lime and magnesia; and meerschaum—a silicate of magnesia. It exists in mineral waters and in the sea as sulphate, and as chloride, the former being known as Epsom salts. It was from the Epsom spring, in 1695, that Drew extracted this well-known salt, and in the beginning of the 18th century *Magnesia alba*, so called to distinguish it from what was already known as *Magnesia nigra* (black oxide of manganese—so called from its resemblance in colour, weight, &c. to the magnet) was discovered. The metal was first prepared by Davy, and for long its manufacture was limited to a small scale. Now, however, it is made in quantity by fusing together the chlorides of potassium and magnesium and fluor spar, and adding metallic sodium with great care. The crude metal is finally distilled and pressed in a semi-fluid state into ribbon or wire.

Magnesium has a silver-white colour, which is tarnished by moist air. It is a very light metal, its specific gravity being only 1.75. It is readily volatile, and, when lighted, burns in air with an intensely brilliant light rich in chemical rays. On this account it was, till superseded by the electric light, much used in photography, while in signalling and pyrotechny it plays an important part.

When magnesium burns in air it forms a white ash consisting of the oxide, magnesia, MgO (which may be also prepared by heating the carbonate). This is a very infusible substance, and is much used in medicine under the name of calcined magnesia. The carbonate, $MgCO_3$, is found in nature, but for medical purposes it is prepared by precipitating a soluble magnesium salt with carbonate of soda. According as it is prepared in the hot or cold, the resulting carbonate forms the ponderous and dense or the light variety.

Although insoluble in water, this substance readily dissolves in water containing carbonic acid, and this solution is known as fluid magnesia. The sulphate, $MgSO_4 \cdot 7H_2O$, or Epsom salts, occurs in nature, and is well known as a domestic remedy. It is much employed in febrile affections, but it may be used in any case in which a mild but efficient laxative is required. Its dose varies from $\frac{1}{4}$ to 1 ounce, but in order to promote its full efficacy it should be taken along with copious draughts of water. In combination with infusion of senna it forms the ordinary black draught. Magnesia and the carbonate are employed in small doses as an antacid, but in larger quantity they have a distinct purgative action. Fluid magnesia (see above) is a valuable aperient for women and children. Citrate of magnesia is the popular name for a granular, effervescent aperient, now much in use. It consists of a mixture of bicarbonate of soda, tartaric and citric acids, sugar, and a small trace (1 to 5 per cent.) of Epsom salts.

Malic Acid, $H_2C_4H_2O_6$ (from Lat. *malum*, 'an apple'), occurs abundantly in most acidulous fruits, particularly in unripe apples, gooseberries, and currants, in which it is found as an acid or acid salt of potash or lime, which gradually changes into a neutral salt as the fruit ripens. It crystallises in groups of radiating acicular prisms, but, as the crystals are very deliquescent, it is usually obtained as a syrupy, semi-transparent mass, with a very sour smell, and readily soluble in water and alcohol. The chemical changes which this acid undergoes under the influence of various reagents are very singular, and serve to illustrate many points in vegetable physiology in reference to the maturation of fruits. Thus, nitric acid converts it into oxalic acid; hydrated potash, into oxalic and acetic acids; ferments, into succinic, butyric, acetic, and carbonic acids and water.

Malleability is the property which certain metals possess of being reducible to thin leaves, either by hammering (hence the corresponding German word, *Hämmerbarkeit*) or by lamination between rollers. The order in which the malleable metals exhibit this property is as follows—Gold, Silver, Copper, Platinum, Palladium, Iron, Aluminium, Tin, Zinc, Lead, Cadmium, Nickel, Cobalt. Gold far surpasses all the other metals in malleability, being capable of reduction into films not exceeding the 200,000th of an inch in thickness; and silver and copper may be reduced to leaves of great tenuity. Although gold and silver also present the property of Ductility (q.v.) in the highest degree, there is no constant relation between the two properties; for example, iron, although it may be reduced to extremely thin wire, is not nearly so malleable as gold, silver, or copper.

Mandrake (*Mandragora officinalis*), a Solanaceous plant closely allied to Belladonna (q.v.). There are two varieties, the vernal and the autumnal; both are natives of the Mediterranean region and the East, and especially abound in Greece. The whole plant has a very fetid narcotic smell;

Mandrake (*Mandragora officinalis*).

and all parts have poisonous properties like those of belladonna, but more narcotic, for which reason a dose of the root was formerly sometimes given to patients about to endure surgical operations. The ancients were well acquainted with the narcotic and stupefying properties of mandrake, and it was a common saying of a sleepy or indolent man that he had eaten mandrake. The large taproot grows somewhat irregularly, and often seems divided into two, through the development of a branch which attains more

or less equal size. Hence arises a rude resemblance to a human figure; and this is easily exaggerated by a little judicious pruning or carving, and by trimming the covering of fine hair-like roots. Hence Pythagoras speaks of the mandrake as *anthropomorphic*. To such mannikin-figures many magical virtues were ascribed: by the ancient Germans they were supposed to bring luck to their possessors, who accordingly dressed and tended them like dolls, yet kept them reverentially enshrined in caskets, and thus obtained their services for the healing of obstinate diseases of man and beast, for the divination of the future, or the ensuring of supplies of money. From the most ancient times aphrodisiac virtues have been ascribed to mandrake, which was therefore supposed to cure barrenness (see Gen. xxx. 14-16); such repute is hardly borne out by the actual properties of the root (which would, however, relax the womb), but probably more commonly depended on its magical associations as a phallic figure. The extremely narcotic and poisonous properties of the plant could not but invest these figures with a more grim significance, of which the medieval imagination made the most. So large, deep, and well fixed a root needs some labour to dig out, and, if torn up by main force, breaks with more or less noise, hence the ancient legend that the mandrake shrieks when torn out of the ground. The subsequent possibilities of accident (not to speak of misuse) can easily be imagined, not only from the sweet and attractive berries, but the leaves, root, or even juice. On the base of caution there arose a whole fantastic ritual: the plant could only be safely dug up at midnight, and when loosened by careful digging should be dragged out of the ground by a black dog, which served as a vicarious substitute for the herbalist, in dread of the mandrake's vengeance.

Manganese (sym. Mn; atomic weight, 55) is one of the heavy metals of which iron may be taken as the representative. It is darker in colour than wrought iron, is capable of a high degree of polish, and is so hard as to scratch glass and steel. It is only feebly attracted by the magnet, and oxidises readily on exposure to the air. The metal occurs in nature in small quantity along with iron in meteoric stones, but may be obtained in large amount by the reduction of its sesquioxide or carbonate by charcoal at an extreme heat.

With oxygen it forms six compounds: manganous oxide, MnO ; manganic oxide, Mn_2O_3 ; manganoso-manganic oxide, Mn_3O_4 ; manganese dioxide, MnO_2 ; manganic anhydride, Mn_2O_3 ; and permanganic anhydride, Mn_2O_7 . Like iron it forms proto-salts, $MnCl_2$, and persalts, Mn_2Cl_2 . It also forms salts derived from an acid, H_2MnO_4 , such as potassium manganate, K_2MnO_4 , and from an acid, $HMnO_4$, as potassium permanganate, $KMnO_4$. The binoxide, MnO_2 , is the chief form in which manganese is found in nature, and is the general source of the other compounds. It is known to

mineralogists as pyrolusite, and in commerce as black manganese or manganese simply. When heated alone or with sulphuric acid it gives off oxygen, and when heated with hydrochloric acid chlorine is evolved. It is largely used in the manufacture of glass, to which it imparts a purple colour. It is also supposed to colour the amethyst.

Manganous oxide, MnO , is an olive-green powder. Its salts are colourless, or of a pale rose colour. The sulphate, $MnSO_4$, in pink crystals, is largely used by the calico-printer for the production of black and brown colours, by decomposing it with bleaching powder or an alkali.

Manganic oxide, Mn_2O_3 , in octahedral crystals, forms the mineral braunite, and in the hydrated form, $Mn_2O_3 \cdot H_2O$, the mineral manganite.

Red oxide of manganese, Mn_2O_4 , is formed when any of the other oxides are heated in the air. It is found in nature as the mineral hausmannite.

Manganic anhydride, Mn_2O_7 , is not known in the free state. It forms a hydrated acid, H_2MnO_4 , which forms salts. Manganate of potassium, K_2MnO_4 , is the best known of these. It is in green crystals, and on allowing its solution to stand exposed to the air it rapidly becomes blue, violet, purple, and finally red, by the gradual conversion of the manganate into the permanganate of potash; on this account it is sometimes called chameleon mineral.

Permanganic anhydride, Mn_2O_7 , is only known in solution or in a state of combination. Its solution is of a splendid red colour, but appears of a dark violet tint when seen by transmitted light. Permanganate of potash, $KMnO_4$, which crystallises in reddish-purple prisms, is the most important of its salts. It is largely employed in analytical chemistry, and is the basis of Condry's Disinfectant Fluid.

Manganese is a constituent of many mineral waters, and is found in small quantity in the ash of most vegetable and animal substances. It is almost always associated with iron. Various preparations of manganese have been employed in medicine. The binoxide has been used as a substitute for bismuth in dyspeptic affections, while various preparations have been tried as substitutes for iron in anemia, but with disappointing results. The manganate and permanganate of potash readily part with their oxygen, and in weak solution are used as disinfecting and astringent lotions.

Menthol is a camphor obtained from oil of peppermint by cooling. It has been used by the Japanese for 200 years and is known by them as *Hakka-no-Hari*; indeed, native gentlemen always went about till recently with a medicine-box containing this drug. The chief source is the *Mentha arvensis purpurea*, the oil of which yields more menthol than that of peppermint. In many nervous affections, such as neuralgia, toothache, headache, &c., menthol in the form of cones often gives instant relief. When the cone is rubbed on the skin a twofold action results. The menthol rapidly evaporates, giving a sensation of cold; but if evaporation be prevented it acts as a rubefacient, producing a feeling of warmth. Menthol has also antiseptic properties, and is used with success in solution in diphtheria, &c. It has an odour resembling but differing from that of oil of peppermint. It is liable to be adulterated with thymol, eucalyptol, &c., and then is often irritating to the skin.

Mercury, or **QUICKSILVER** (sym. Hg ; atomic weight = 200; sp. gr. 13.6), one of the so-called noble metals, remarkable as being the only metal that is fluid at ordinary temperatures. It is of a silvery white colour, with a striking metallic lustre. When pure it runs in small spherical drops over smooth surfaces; but when not perfectly pure the drops assume an elongated or *tailed* form, and often leave a gray stain on the surface of glass or porcelain. Moreover, the pure metal, when shaken with air, presents no change upon its surface; while if impure it becomes covered with a gray film. It is slightly volatile at ordinary temperatures, and at $662^\circ F.$ it boils, and forms a colourless vapour of sp. gr. 6.976. Hence it is capable of being distilled; and the fact of its being somewhat volatile at ordinary temperatures helps to explain its pernicious effects upon those whose trades require them to come much in contact with it—as, for example, the makers of barometers, looking-glasses, &c. At a temperature of $-39^\circ F.$ it freezes, when it contracts considerably, and becomes malleable. In consequence of the uniform rate at which it expands when heated, from considerably below 0° to above 300° , it is employed in the construction of the mercurial thermometer.

All mercurial compounds are either volatilised or decomposed by heat; and when heated with carbonate of soda they yield metallic mercury. Native or virgin quicksilver only occurs in small quantity, usually in cavities of mercurial ores. Of these ores by far the most important is Cinnabar (q.v.). There are two means of obtaining the metal from the cinnabar: the ore may be burned in a furnace, in which case the sulphur is given off as sulphurous acid, and the mercury is collected in a condensing chamber; or the ore may be distilled with some substance capable of combining with the sulphur—as, for example, with slaked lime or iron filings. The mercury as imported is usually almost chemically pure. If the presence of other metals is suspected, it may be pressed through leather, redistilled, and then digested for a few days in dilute cold nitric acid, which exerts little action on the mercury if more oxidisable metals are present; or better, in a solution of mercuric nitrate, which deposits mercury and takes up the more oxidisable metals. The mercury, after being washed with water, is chemically pure.

Mercury is first spoken of by Theophrastus (3d

century B.C.); the name *hydrargyros* (whence comes the symbol Hg) dates from Dioscorides. Greeks and Phœnicians procured cinnabar from Almaden in Spain. After the discovery of the New World, the mercury of Peru was famous. California now produces the great bulk of the mercury of commerce, and most of it comes from the New Almaden mine. The total produce of California was 60,851 flasks (of $76\frac{1}{2}$ lb. each) in 1881; in 1888 it had sunk to 33,250 flasks (value \$1,413,125).

There are two oxides of mercury, the black suboxide, Hg_2O , and the red oxide, HgO . Both of these lose all their oxygen when heated, and form salts with acids. The black suboxide, although a powerful base, is very unstable when isolated, being readily converted by gentle warmth, or even by mere exposure to light, into red oxide and the metal: $Hg_2O = HgO + Hg$. The most important of its salts is the nitrate, $Hg_2(NO_3)_2 + 2Aq$, from whose watery solution ammonia throws down a black precipitate known in pharmacy as *Mercurius solubilis Hahnemanni*, from its discoverer, and consisting essentially of the black suboxide with some ammonia and nitric acid, which are apparently in combination. Of the red oxide the most important salts are the nitrate, $Hg(NO_3)_2 + 8Aq$; the sulphate, $HgSO_4$, which is employed in the manufacture of corrosive sublimate; and the basic sulphate, $HgSO_4 \cdot 2HgO$, which is of a yellow colour, and is known as *Turpeth Mineral*.

The haloid salts of mercury correspond in their composition to the oxides. Of the most important of these—the chlorides—there are the subchloride, Hg_2Cl_2 , well known as Calomel (q.v.), and the chloride, $HgCl_2$, or corrosive sublimate.

The chloride, $HgCl_2$, when crystallised from a watery solution occurs in long white glistening prisms; but when obtained by sublimation it occurs in white transparent heavy masses, which have a crystalline fracture, and chink with a peculiar metallic sound against the sides of the bottle in which they are contained. This salt melts at $509^\circ F.$, and volatilises unchanged at about 570° . It has an acrid metallic taste. It is soluble in sixteen parts of cold, and in less than three parts of boiling water, and dissolves very freely in alcohol and in ether. Corrosive sublimate enters into combination with the alkaline chlorides, forming numerous distinct compounds. (A double chloride of ammonium and mercury, represented by the formula $CH_3NCl \cdot HgCl_2 + Aq$, has been long known as *sal alembrothi*.) It combines with oxide of mercury in various proportions, forming a class of compounds of great interest in theoretical chemistry, termed *oxychlorides of mercury*. On adding a solution of corrosive sublimate to a solution of ammonia in excess, a compound, which from its physical characters is termed *white precipitate*, is thrown down, the composition of which is $HgN_2H_4Cl_2$. Chloride of mercury coagulates albumen, and combines with the albuminous tissues generally, forming sparingly soluble compounds. Hence, in cases of poisoning with the salt, the white of raw eggs is the best antidote; and for the same reason corrosive sublimate is a powerful antiseptic, and is employed to preserve anatomical preparations.

Amongst the most important tests for this substance, which is not unfrequently used as a poison, may be mentioned (1) iodide of potassium, which, when added to a crystal or to a watery solution of chloride of mercury, gives rise to the formation of a bright scarlet iodide of mercury. (2) The galvanic test, which may be applied in various ways, of which the simplest is the 'guinea and key test,' devised by Wollaston. He placed a drop of the fluid suspected to contain corrosive sublimate on a guinea, and simultaneously touched it and the surface of the guinea with an iron key; metallic mercury was deposited on the gold in a bright silvery stain. (3) Precipitation on copper, and reduction. To apply this test we acidulate the suspected fluid with a few drops of hydrochloric acid, and introduce a little fine copper gauze, which soon becomes coated with mercury. On heating the gauze in a reduction tube the mercury is obtained in well-defined globules.

With iodine and bromine mercury forms two iodides and bromides, corresponding in composition to the chlorides. Both the iodides are used in medicine; the bromides are of no practical importance. The subiodide, Hg_2I_2 , is a green powder formed by triturating 5 parts of iodine with 8 of mercury, and is of far less interest than the iodide, HgI_2 , which is most simply obtained by pre-

cipitating a solution of corrosive sublimate by a solution of iodide of potassium. The precipitate is at first salmon-coloured, but soon changes into a brilliant scarlet crystalline deposit.

Sulphur forms two compounds with mercury—viz. a subsulphide, Hg_2S , a black powder of little importance, and a sulphide, HgS , which occurs naturally as Cinnabar (q.v.). Sulphide of mercury is thrown down as a black precipitate by passing sulphuretted hydrogen through a solution of a persalt of mercury (corrosive sublimate, for example). When dried and sublimed in vessels from which the air is excluded, it assumes its ordinary red colour. The well-known pigment *vermilion* is sulphide of mercury, and is sometimes obtained from pure cinnabar, but is more frequently an artificial product.

Mercury unites with most metals to form Amalgams (q.v.), several of which are employed in the arts. Of the numerous organic compounds of mercury it is unnecessary to mention more than the Fulminate (q.v.) and the cyanide, $HgCy$, which may be prepared by dissolving the red oxide of mercury in hydrocyanic acid, and is the best source from which to obtain cyanogen.

The uses of mercury are so numerous that a very brief allusion to the most important of these must suffice. It is employed extensively in the extraction of gold and silver from their ores by the process of amalgamation. Its amalgams have been largely employed in the processes of silvering and gilding, and some (as those of copper and cadmium) are employed by the dentist for stopping teeth. It is indispensable in the construction of philosophical instruments, and in the laboratory in the form of the mercurial bath, &c. It is the source of the valuable pigment vermilion. The use of its chloride in anatomical preparations has been already noticed; it is similarly found that wood, cordage, and canvas, if soaked in a solution of this salt (1 part to 60 or 80 of water), are better able to resist decay when exposed to the combined destructive influence of air and moisture.

MEDICINAL USES OF MERCURY AND MERCURIALS.—Metallic mercury is used in medicine in a state of very fine division in the form of gray powder, blue pill, mercurial ointment, and other preparations. It is also used as mercurous and mercuric oxides and salts. As with other metals, the mercurial preparations have a local action and an action after absorption into the blood. The intensity of the local action varies, however, with the individual preparation; the persalts being soluble in water, and hence capable of precipitating albumen at once, are very irritating, while the mercurous salts and uncombined mercury, being insoluble in water, exert an effect only in so far as they are dissolved in the secretions. These differences in local action have a very great influence in determining their applications in medicine.

Locally, the various ointments, liniments, and plasters are used as stimulants, astringents, antiseptics, and parasitocides, the persalts are used as antiseptic lotions, while the protosalts are little employed locally, except Calomel (q.v.) in powder.

Absorption of mercurial preparations from the intestinal canal or skin takes place very readily, and in an hour or less the mercury may be detected in most of the secretions. After absorption into the blood all the preparations have the same action. In minute doses they act as alteratives, improving nutrition. In larger doses, such as are ordinarily used, they also exert profound alterative effects; but care must be exercised in their administration, otherwise symptoms of chronic poisoning are apt to ensue. These consist in excessive salivation, inflammation of the mouth and gums, and dyspepsia, while in severer cases caries of bone, nervous symptoms, a watery condition of the blood, albuminuria, cachexia, and other serious complications may occur. The mercurial preparations are given internally in syphilis, in serous inflammations, and in dropsy as diuretics. Certain of them, such as gray powder, blue pill, and calomel, are used as purgatives and as intestinal antiseptics.

The doses of the different preparations vary greatly, those of the persalts being very much smaller than in the case of the other preparations. Some persons are peculiarly susceptible to the action of mercurials, and show symptoms of chronic poisoning after very small amounts.

With regard to acute mercurial poisoning, this is due to irritation of the intestinal canal, and is only seen with the soluble salts when taken in over-

doses. The perchloride (corrosive sublimate) has been most frequently employed for the purpose of poisoning. The symptoms come on immediately, with a burning pain in the throat and violent pain in the abdomen, with severe vomiting and purging. There is always a good deal of collapse. Albumen, in the form of white of egg, is the best antidote.

Metallurgy. A brief account will be given here of ancient metallurgy and of that department of modern metallurgy relating to the mechanical treatment of ores.

Ancient Metallurgy.—From an ethnological point of view one of the most interesting questions connected with the origin of the industrial arts is when, and under what circumstances, man first began to work metals by softening or melting them by means of a high heat. The art of smelting ores was probably discovered by observing the effect of a big fire on some rich ore that happened to be in the way. Gold is always found native, and silver and copper sometimes. The ancient Egyptians worked in gold, silver, and bronze with a degree of skill that could only have been reached by gradual steps extending over thousands of years. In the notes to his edition of *Wilkinson's Ancient Egyptians*, Dr Birch says that it is uncertain whether metallic tin was known to them, as bronze (q.v.) may have been made by the use of tin ore along with copper. He also states that the question of the use of iron among them has been rendered doubtful by the few specimens of that metal found in the monuments and sepulchres. Some examples, however, have been met with, although only in one case apparently is the approximate age of the object known. It is iron wire in a bronze statue of the time of the Ramesids. In India and some other parts of Asia malleable iron is made directly from rich ores in furnaces scarcely bigger than chimney-cans, by a process in use from time immemorial; and by a similar process savages in some parts of Africa also smelt iron. It is supposed by some archaeologists that most parts of Africa passed directly from the stone to the iron age, but there seems to be evidence that in some places on that continent the making of various articles of the copper of the country has been long practised by aboriginal tribes.

Among the remains found in the lake-dwellings of central Europe are crucibles for melting metals, ingots of copper and tin, and in one crucible traces of gold were found. Bronze implements are abundant, but the considerable number of copper hatchets which have now been discovered has raised the question as to whether in prehistoric times a copper age has not preceded those of bronze and iron. Copper is more easily smelted than iron; and bronze, being an alloy of copper and tin, must somewhere have been preceded in its application to hatchets or other articles by unalloyed copper, although this may not have been the case in Europe. Some copper hatchets, and other implements of this metal, are the only evidence we have that the ancient Mexicans made any use of metal tools; though their artificers were skilled in casting gold and silver, and in hammered work and chasing, and tin as well as copper ore was mined, and the two combined as bronze. The early tribes inhabiting the country about Lake Superior, where native copper is plentifully found, made knives and ornaments of the metal by hammering it cold, in some cases, it is believed, with stone implements. Small chisels, rings, idols, and other objects made of gold and of ancient date, some of which are of thin, flat beaten plates, have been obtained in the republic of Colombia, South America. Silver articles of a rude archaic character appear to be rare. It is likely that the working of these native metals in the cold state in certain limited areas preceded the art of manipulating any metal by heat.

See Lubbock's *Prehistoric Times*, Munro's *Lake-dwellings of Europe*, Nadaillac's *Prehistoric America*, and various papers in the volumes of *Contributions to Knowledge* published by the Smithsonian Institution.

Modern Metallurgy.—As now understood this is the art of extracting metals from their ores. The operations are partly mechanical and partly chemical. Those processes which depend principally on chemical reactions for their results have reference chiefly to the roasting and smelting of ores, and are described under the heads of the different metals. But there are certain preliminary operations of a mechanical kind which metallic ores undergo, such as crushing, jigging, washing, &c., which we shall describe here, as they are essentially the same for the ores of lead, copper, tin, zinc, and indeed most

of the metals. Until comparatively recent times ore, or rather ore-gangue, as it came from the mine was in the first instance broken by hammers before being passed on to crushing-rollers or stamps to be reduced to smaller pieces or grains. In the year 1858 Mr E. W. Blake of New Haven, Connecticut, invented a stone or ore crusher which has become so extensively used that it has, except in special cases, superseded hand-labour for breaking up large pieces of ore. Fig. 1 shows in section a modification of Blake's ore-crusher, made by Marsden of

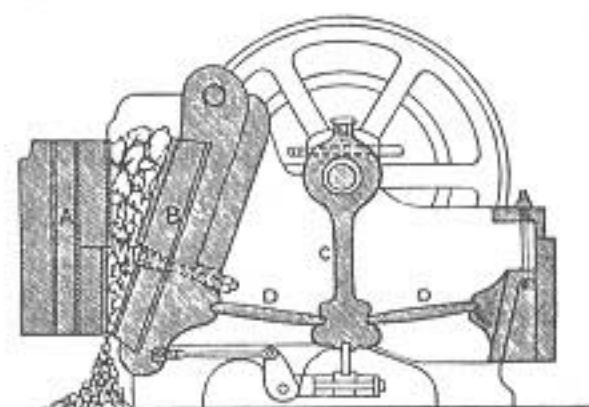


Fig. 1.

Leeds. The shaded portion shows the fixed jaw, A, and the movable jaw, B, between which the ore or stone is crushed. To the movable jaw a rapid biting movement (reaching 250 strokes per minute) is given by means of an eccentric lever and toggle-joints. C is the rod connecting the eccentric with the toggle-plates, DD. The machine is driven by a shaft and pulley, and has a balance-wheel. A spring or lever near the base of the machine aids the return movement of the jaw, B.

The vein-stuff or impure ore is next taken either to the crushing-rollers or to the stamping-mill. Fig. 2 shows a section of a crushing-mill of German design, but nearly resembling that in use in Cornwall for treating copper, lead, and zinc ores. The ore, already reduced by the Blake jaw-crusher to pieces roughly $1\frac{1}{2}$ inch in diameter, is raised to the floor or platform, *b, b*, and by means of an opening at *c* passed down to the crushing-rollers, *r, r*. These are usually from 10 to 30 inches in diameter and at least 10 inches long, made of chilled cast-iron or steel, and with a lever at *d* to keep them in position. Below the rollers a shoot conveys the crushed ore to a series of sieves increasing in fineness from the top to the bottom, and what is separated by each sieve falls into a separate pit. Such pieces

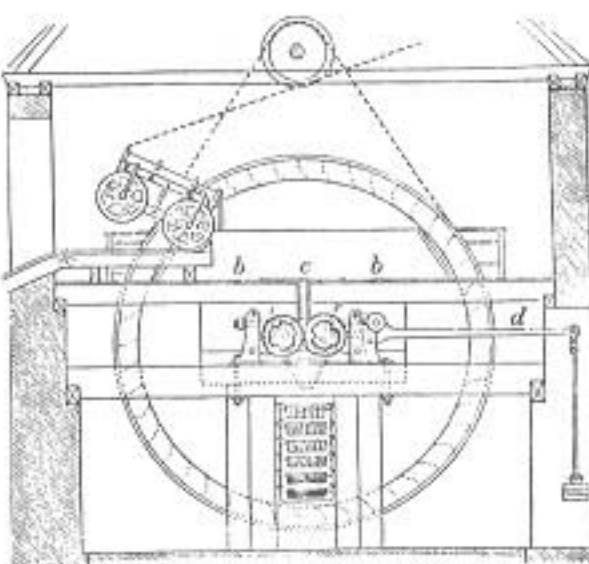


Fig. 2.—Ore-crushing Mill:

End view of the crushing-rollers, sieves, and bucket-wheel.

of ore-stuff as are too large to go through the top sieve or riddle fall into the raff-wheel or bucket-wheel, and are by it raised again to the floor to be re-crushed. In Cornwall a sieve or riddle cylindrical in shape is used, and it slopes so that stuff too large to go through its meshes is raised by the raff-wheel to get a second crushing. Only about 13 per cent. of the ore-stuff crushed in the Cornish mill exceeds $7\frac{1}{2}$ millimetres in size.

For pulverising some ores—tinstone and auriferous quartz, for example—a stamping-mill is used. It consists of a series of upright shafts with a

weighty piece of iron at the bottom of each. They are raised by means of an axle with projecting cams, and then falling by their own weight act like hammers. Except in chlorination and amalgamation works (see GOLD), the wet process of stamping is generally adopted—that is, the cast-iron or steel shoes of the stamps work upon cast-iron or quartz bottoms placed in stamp-troughs filled with water.

Sizing apparatus or sorting machines are employed for dividing the crushed ore-stuff into grains of several sizes. A common hand-riddle is the simplest form of sizing implement. One kind of apparatus in use consists of a series of flat-bottomed sieves with graduated meshes placed on different levels and mechanically agitated so as to pass the stuff across the perforated bottoms. The first sieve separates the largest grains, the second the next in size, and so on. A rotating drum-sieve or trommel is, however, more frequently employed. It is placed horizontally, and is to some extent conical in shape. Sometimes it is one long continuous trommel in sections, in which case the finest stuff passes through the first section, the next larger through the second, and so on through, say, five or six divisions to the largest grains. In other cases a system of separate conical trommels, in which the sizing takes place from large to small grains, is employed. With the trommel water is used, and, although its axis may be quite level, the falling angle of its shell together with its motion impels the ore-stuff from the smaller to the larger end. Trommels are used for clearing off earthy matter and for draining off water from ore as well as for sizing.

After the ore-stuff has been sorted according to the size of the grains, the next step is to separate by specific gravity the pure ore from the gangue or non-metallic minerals associated with it. If the reduced particles be those of vein-stuff containing more than one kind of ore, these are also separated by gravity. If equal-sized grains of galena, blende, and quartz, whose respective densities are 7.5, 4, and 2.7, are allowed to fall freely in some depth of water, the three substances will separate into layers at the bottom, in which case the lead ore (galena) will form the lowest, the zinc ore (blende) the middle, and the quartz the top layer. But in hydraulic jiggers (some are pneumatic) the column of water, at most under 3 inches, is too shallow to admit of separation by simply dropping the grains. Consequently these are placed in a sieve immersed in water, and subjected to a repeated up-and-down motion, in which the ascent of the jiggering stuff takes place by jerks, but in the descent it falls freely. In this way the pure ore, or at least the best ore, accumulates at the bottom, and is usually sufficiently rich for smelting. The gangue on the surface is skimmed off or otherwise removed. In hand-jiggering the sieve is vigorously jerked in a tub of water; in the brake-jigger the jerking motion is produced by a hand-lever and connecting rod; and in continuous jiggers mechanical contrivances are used to carry into different receptacles the mineral grains separated upon the sieve in layers without interrupting the jiggering process.

The dressing of fine sandy, mealy, or slimy ore-stuff, which is not suitable for jiggering, is effected on buddles or sloping tables. Buddles are inclined planes, often circular, or rather conical in shape, over which the fine stuff suspended in water descends. In doing so the heavier metallic particles fall at the top of the table or cone while the lighter waste is carried down to the foot.

Metals. Although each metal is considered in a separate article, there are various points regarding the general physical and chemical characters of these bodies, and the method of classifying them, which require notice. A metal, from the chemical point of view, is an element which can replace hydrogen in an acid and thus form a salt. Hydrogen itself is, chemically, considered to be a metal. Those elements which are non-metallic in this sense are called *metalloids*.

Amongst the chief *chemical* properties of metals we notice their strong affinities to certain of the non-metallic elements. All the metals, without exception, combine with oxygen, sulphur, and chlorine, and often in several proportions, forming oxides, sulphides (formerly termed sulphurets), and chlorides. Many of them combine with bromine, iodine, and fluorine. The other compounds of this nature, excepting carbide (formerly carburet) of iron, or steel, and the hydrides of arsenic and antimony (commonly known as arseniuretted and antimonuretted hydrogen), which are of importance in toxicology.

cology, may be passed over without notice. The metallic oxides are, without exception, solid bodies, white or coloured, and usually present an earthy appearance. Hence the old name of *metallic calx* applied to these oxides. Those oxides which are termed basic possess the property of directly uniting with the so-called oxy-acids (such as sulphuric, nitric, carbonic, and silicic acid), and of forming new chemical compounds of the second order, termed Salts (q.v.). The compounds of the metals with chlorine, iodine, bromine, and fluorine—such, for instance, as chloride of sodium, or common salt, ClNa —are termed haloid salts. The same metal may often combine both with chlorine and with oxygen in more than one proportion. For example, we have subchloride of mercury, Hg_2Cl_2 ; suboxide of mercury, Hg_2O ; chloride of mercury, HgCl_2 ; oxide of mercury, HgO . For the compounds of the metals with sulphur, see SULPHUR.

The following are the most important of the physical properties of the metals: (1) All metals, unless when they are in a finely-pulverised form, exhibit more or less of the characteristic lustre termed metallic. Two of the non-metallic elements, iodine and carbon, in some forms also present a metallic lustre. (2) All metals are good conductors of heat and electricity, although in very unequal degrees. (3) With the exception of mercury, all the metals are solid at ordinary temperatures. With the exception of gold, copper, calcium, and strontium, the metals are, when light is only once reflected from them, more or less white, with a tendency to blue or gray. Most of them have been obtained in crystals, and probably all of them are capable of crystallising under certain conditions. (4) Metals are remarkable for their opacity, except when they are chemically reduced to extremely thin films. (5) All the metals are fusible, although the temperatures at which they assume the fluid form are very different (see MELTING-POINT); and some of them, as mercury, arsenic, cadmium, zinc, &c., are also volatile. (6) Great weight, or a high specific gravity, is popularly but erroneously regarded as a characteristic of a metal; while platinum, osmium, and iridium (the heaviest bodies known in nature) are more than twenty times as heavy as water, lithium, potassium, and sodium are actually lighter than that fluid. (7) Great differences are observable in the hardness, brittleness, and tenacity of metals. While potassium and sodium may be kneaded with the finger, and lead may be marked by the finger-nail, most of them possess a considerable degree of hardness. Antimony, arsenic, and bismuth are so brittle that they may be easily pulverised in a mortar; while others, as iron, gold, silver, and copper, require great force for their disintegration. Taking iron and lead as representing the two extremes of tenacity, it is found that an iron wire will bear a weight twenty-six times as heavy as a leaden wire of the same diameter.

Metals enter into combination with one another when they are fused together, and such combinations are termed *Alloys* (q.v.), unless when mercury is one of the combining metals, in which case the resulting compound is termed an *Amalgam* (q.v.). It is doubtful whether all alloys are true chemical compounds. Definite compounds of the metals with each other do, however, certainly exist, and are sometimes found native, as, for example, the crystallised silver and mercury compound represented by the formula AgHg .

In consequence of their strong affinities for the metalloids the metals are seldom found in a free or uncombined state, even in the inorganic kingdom, and never in animals or plants. The more common metals, in consequence of their strong affinity for oxygen and sulphur, are very rarely met with in the uncombined state; but some of those which are less abundant, such as gold, silver, and platinum, are found uncombined, in which case the terms *native* and *virgin* are applied to them; and other metals, as mercury and copper, occur both in a free and in a combined state. Many native alloys are found, but the ordinary sources of the metals are oxides, sulphides, chlorides, and carbonates, sulphates, and other salts. These are termed the *ores* of the metals. The methods of obtaining the metals from their various ores fall under the head of METALLURGY.

Various classifications of the metals have been suggested by different chemists. The following is probably one of the most convenient:

(I.) The *Light Metals*, subdivided into—

(1) The metals of the alkalis—viz. potassium, sodium, cesium, rubidium, lithium.

(2) The metals of the alkaline earths—viz. barium, strontium, calcium, magnesium.

(3) The metals of the true earths—viz. aluminium, glucinum, zirconium, yttrium, erbium, terbium, thorium, cerium, lanthanum, didymium.

(II.) The *Heavy Metals*, subdivided into—

(1) Metals whose oxides form powerful bases—viz. iron, manganese, chromium, nickel, cobalt, zinc, cadmium, lead, bismuth, copper, uranium, thallium.

(2) Metals whose oxides form weak bases or acids—viz. arsenic, antimony, titanium, tantalum, niobium (or columbium), tungsten, molybdenum, tin, vanadium, osmium.

(3) Metals whose oxides are reduced by heat—noble metals—viz. mercury, silver, gold, platinum, palladium, iridium, ruthenium, rhodium, osmium. (Several of the rare metals are here omitted.)

Another classification is that by which the metals are arranged in six groups, each group being named after a metal which possesses the common characters in a well-marked degree: viz. (1) the sodium group, (2) the calcium, (3) the iron, (4) the copper, (5) the platinum, and (6) the antimony groups.

Metal-work, ARTISTIC. Leaving celebrated statues and groups cast in bronze to be described under the head SCULPTURE, we shall briefly notice here a few important examples of artistic work in metal which are rather classed as specimens of decorative art than of pure sculpture. Of early gold and silver work one of the most renowned objects is the altar made of these two metals in the church of St Ambrose at Milan. It was executed by Wolvius in the 9th century, and contains figures in relief of Christ and the Apostles with ornamental borders in enamel. Another very fine example of work in gold and enamel is the *Pala d'Oro* (altar front) of St Mark's, Venice, by Byzantine artists of the 10th or 11th century. Some specimens of Celtic art, partly in precious metal, such as the Tara Brooch and the Ardagh Chalice—the latter supposed to be of the 10th century—are of exquisite beauty (see BROOCH). The shrine of the Magi in Cologne Cathedral is a magnificent reliquary of the 12th century, in which the figures are of gold and the architectural decorations covered with enamels and precious stones. A considerable number of specimens of ecclesiastical gold and silver work of the 13th century remain, including a few of great interest. Of 14th-century examples—a time when the goldsmith's art ceased to be employed exclusively in the service of the church—the splendid silver reliquary in the church of Orvieto, by Ugolino of Siena, is very remarkable. Perhaps the two most important monuments of the goldsmith's art made in the middle ages are the altar of St James, Pistoia, and that of the Baptistery of St John at Florence. They were begun in the 14th century, and a number of the most famous Italian artists were in succession engaged upon them for a period of 150 years. Both are of silver, one of them being decorated with subjects from the life of St James, and the other with scenes from the life of St John. Giglio of Pisa, Pietro Tedesco, Ricciardi, Cipriano, and Filippo were among the artists engaged on the St James' altar; and Cioni, Ghiberti, Cenni, Verrocchio, and Pollaiuolo worked at that of St John. Some of the greatest artists in Italy in the 14th and 15th centuries practised to some extent the goldsmith's art, including Luca della Robbia, Ghiberti, Brunelleschi, Donatello, and Jacopo della Quercia. In the 16th century Cellini's is the greatest name, although well-authenticated works by him in the precious metals are few in number. There are some very artistic productions in pewter by the French artist François Briot, who lived in the 16th century.

Bronze is a metal in which many fine works have been executed, and these are often of large size. Few early examples exist of which the artists are known. Stanracius of Constantinople cast in the 11th century the bronze gates of St Paul's-without-the-Walls at Rome, destroyed in 1823, but of which drawings exist. A century later an artist named Barisanus made the fine bronze door of the cathedral of Monreale in Sicily. One of the most artistic productions in this metal of the 13th century is the candelabrum in Milan Cathedral, 15 feet high. The east door of the Baptistery at Florence, upon which Ghiberti was engaged from 1425 to

1452, is considered a marvellous work of art. Another door in this building, by A. Pisano, completed in 1430, after being in progress for twenty years, is also an admirable production. P. Vischer's shrine of St Sebald at Nuremberg is a beautiful monument which, though quite different in form from the objects named above, resembles them in the design being an intimate combination of small works in sculpture and architectural ornament. A fountain in the Maximilian-strasse, Augsburg, executed by H. Gerhard in 1593, has been much admired. For want of space we can only name two more bronzists—B. Morel, who did the great candelabrum in Seville Cathedral, and L. Bernini, who in the 17th century executed many clever works in Italy.

There is perhaps no class of metal objects in which artistic skill is more marvellously displayed than in some of the rich suits of armour made in the end of the 15th, but chiefly in the 16th century. These are for the most part of iron or steel, with ornament in *repoussé* or engraved; sometimes with both combined, and occasionally with damascening in gold and silver. Among those who practised the armourer's art in Italy the most famous names are Michelagnolo, Filippo Negrolo, Romero, and some members of the Piccinini family. In Germany Kollman of Augsburg, and in France Antoine Jacquard stood high. Some of the finest suits of armour made at this period are in the Museum of Arms at Dresden, and in the Louvre and Musée d'Artillerie, Paris.

Wrought-iron work, rude but effective, appears on the wooden doors of some Romanesque churches of the 12th century. In the 13th and 14th centuries the work in this metal became more refined, and among admirable examples of the latter period may be mentioned the screens round the tombs of the Scala family at Verona, and a screen in the church of Santa Croce, Florence. Screens, grilles, and other objects with open wrought-iron ornament, beautifully designed, and ranging over a period from the 13th to the 16th century, but especially those made during the 15th and 16th, are found in many churches in Germany, Spain, France, and England. In the latter country the early grille over Queen Eleanor's tomb, Westminster, and the later screen to Edward IV.'s at Windsor are fine examples; so also are the still later (18th century) railing-panels made for Hampton Court Palace by Huntington Shaw. The canopy of a draw-well at Antwerp by Quentin Matsys is one of the best works of its kind in hammered iron. Many of the elaborately chiselled iron locks and hinges made at Nuremberg and Augsburg in the 15th and 16th centuries are wonderfully beautiful. The National Museum at Munich is especially rich in specimens of these.

Methyl is an organic radical homologous with Ethyl (q.v.). Its formula is CH_3 , but, as it cannot exist in the free state, two such groups of atoms unite together to form ethane, CH_3-CH_3 . As in the case of ethyl, methyl is the centre of a whole group of substances known as the methyl-group. Thus, the hydride of methyl, CH_3H , known as light carburetted hydrogen, marsh-gas, or fire-damp, is well known as the cause of explosions in coal-mines. It is a light, inodorous gas, half as heavy as air; non-poisonous and very inflammable, forming an explosive mixture with seven volumes of air. Methyl alcohol, CH_3OH , is obtained as a by-product in the manufacture of beet-root sugar, and also by the dry distillation of wood. It is a colourless, mobile liquid, resembling ordinary alcohol in many of its properties. Methyl oxide or methyl ether, $(\text{CH}_3)_2\text{O}$, corresponding to ethyl ether or common ether, is a gas at ordinary temperatures, very soluble in water and alcohol, and capable of being condensed to a liquid by pressure and cold. It is largely prepared for use in freezing-machines, owing to the intense cold which results when the liquefied gas is allowed to evaporate. It is prepared by the action of sulphuric acid on wood spirit.

Besides the above, methyl enters into the constitution of many ethereal salts and amines, such as methyl chloride, acetate, and salicylate, as well as methyl amine, dimethyl amine, &c. (see AMINES). The salicylate, $\text{CH}_3\text{C}_7\text{H}_5\text{O}_2$, is interesting as being the ethereal oil of *Gaultheria procumbens*, from which pure methyl alcohol and pure salicylic acid can both be made. For Methyl Violet, see DYING; and for Methylene, see ANÆSTHESIA.

Methylated Spirit consists of a mixture of 9 parts of alcohol, of specific gravity 0.920, with 1 part of Pyroxylic (q.v.) or wood-spirit. This addition of wood-spirit renders it unfit for drinking, although it scarcely interferes with its power as a solvent. It is allowed by the excise to be sold duty-free for manufacturing purposes, and for preserving specimens in museums.

Microcosmic Salt is used in blowpipe analysis, and may be prepared by mixing concentrated solutions of phosphate of soda and chloride of ammonium. It has the composition $\text{NaNH}_4\text{HPO}_4 \cdot 4\text{H}_2\text{O}$.

Micrometer (Gr. *mikros*, 'little'; *metron*, 'measure') is an instrument used for the measurement of minute distances and angles. Its different forms, depending on different principles, may be divided into two sections, according as they are applied to physics or astronomy. Of the former section are the Vernier (q.v.) and the Micrometer Screw, the latter instrument being merely a screw with a very regular thread, and a large round head, which is carefully graduated, generally to sixtieths, and furnished with an index. It is easily seen that if a complete turn of the screw advance its point $\frac{1}{60}$ of an inch, a turn sufficient to pass the index from one graduation to another will only advance it $\frac{1}{60}$ of an inch, &c. This is the micrometer used in the construction and graduation of instruments. Of those applied to astronomical purposes the most simple is a short tube, across the opening of which are stretched two parallel threads, which are moved to or from each other by screws. These threads are crossed by a third perpendicularly, and the whole apparatus is placed in the focus of a lens. The distance of two stars is found by adjusting the two parallel threads, one to pass through the centre of each star, taking care that the threads are placed perpendicular to the line joining the stars, and finding how many turns and parts of a turn of the screw are required to bring the wires to coincide. The angle of position of two stars is also obtained by turning round the instrument till the third wire, which is normally horizontal, bisects both stars, and reading off on the circumference the arc passed over. *Fraunhofer's suspended annular micrometer* consists merely of a steel ring surrounded by a flat rim of glass, and the position of the star is deduced from the time when it crosses the ring and its path while within it. The Abbé Rochon substituted for the wire micrometer one made of two prisms of rock-crystal or Iceland spar, capable of double refraction.

Microscope (Gr. *mikros*, 'small'; and *skopeo*, 'I see') is an instrument for enabling us to examine objects which are so small as to be almost or quite undiscernible by the unaided eye. Its early history is obscure; but, as it is quite evident that the property of magnifying possessed by the lens must have been noticed as soon as it was made, we are quite safe in attributing its existence in its simplest form to a period considerably anterior to the time of Christ. It is generally believed that the first compound microscope was made by Zacharias Jansen, a Dutchman, in the year 1590, and was exhibited to James I. in London by his astronomer, Cornelius Drebbel, in 1619. It was then a very imperfect instrument, colouring and distorting all objects. For many years it was more a toy than a useful instrument, and it was not until the invention of the achromatic lens by Chester Moor Hall (1729) and John Dollond (1752-57), and its application to the microscope by Lister and others, that it reached the advanced position it now occupies among scientific instruments.

An object to be magnified requires simply that it be brought nearer to the eye than when first examined; but as the focal distance of the eye ranges from 6 inches to 14 inches—10 inches being the average focal distance—it follows that a limit to the magnifying power of the eye is attained whenever the object to be examined is brought too near. If, however, we blacken a card, and pierce a hole in it with a fine needle, and then examine a minute object, as, for instance, the wing of an insect held about an inch from the card, we shall see it distinctly, and that, too, magnified about ten times its size. This is explained by the fact that the pin-hole limits the divergence of the pencil of rays from each point of the object, so that the eye can converge it sufficiently on the retina to produce a distinct impression, which is faint; and did not

the blackened card exclude all other light it would be lost. If we now remove the blackened card without either moving our eye or the object under examination, it will be found that the insect's wing is almost invisible, the unaided eye being unable to see clearly an object so near as one inch; thus demonstrating the blackened card with the needle-hole in it to be as decided a magnifying instrument as any set of lenses.

In fig. 1 AB is a double convex lens, in front of which, between it and its focus, K, but near that focus, we have drawn an arrow, EF, to represent the object under inspection. The cones drawn from its extreme points are representative rays of light, diverging from these points and falling on the lens. These rays, if not interrupted in their course by the lens, AB, would be too divergent for the eye to bring them to a focus upon the retina (see EYE). But after traversing the lens, AB, they travel, if the object be sufficiently near the focus, K, in lines which are nearly parallel, or which apparently diverge from points, such as C, D, not nearer to the eye than the least distance of distinct vision, which is, for most individuals, about ten inches. Suppose the lens is as close as may be to the eye, and that the object, EF, is brought up to it to such a distance that the virtual image, CD, is at 10 inches' distance from the eye; and let us further suppose that the focal length of the lens is such (see LENS)

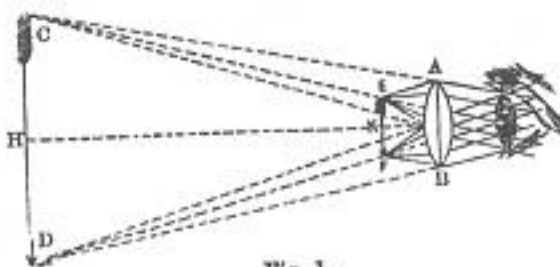


Fig. 1.

that the image, CD, is ten times, linearly, as great as EF; then the eye, instead of vainly striving to see the small object, EF, near K, will seem to perceive distinctly an image ten times as great linearly, and situated at the convenient distance, H. The magnification of the lens is independent of the eye, and is the relation between the size of the image and that of the object. When one of these is at an infinite distance and the other at a principal focus, the magnifying power depends on the position of the eye, and is the ratio between the apparent size of the object at any given distance and that of the virtual image as seen with the aid of the lens; this may be seen to increase as the eye is withdrawn to a greater distance, especially when the one eye is used to look at the object, say a page of print, and the other to look through the lens; but the greatest retinal image is formed when the lens is close to the eye.

We have supposed the whole of the light to enter the eye through the lens, AB (fig. 1); but so large a pencil of light passing through a single lens would be so much distorted by its spherical figure, and by the chromatic dispersion of the glass, as to produce a very indistinct and imperfect image. This is partly rectified by applying a stop to the lens, so as to allow only the central portion of the pencil to pass. But, while such a limited pencil would represent correctly the form and colour of the object, so small a pencil of light is generally unable to illuminate the whole of the magnified picture with any adequate degree of brilliancy, and is therefore incapable of displaying those organic markings on animals or plants which are often of so much importance in distinguishing one class of objects from another. Dr Wollaston was the first to overcome this difficulty, which he achieved by constructing a doublet (fig. 2), which consists of two plano-convex lenses, having their focal lengths in the proportion of 1 to 3, and placed at a distance best ascertained by experiment. Their plane sides are placed towards the object, and the lens of shortest focal length next the object. By this arrangement the distortion caused by the first lens is corrected by the second, and a well-defined and illuminated image is seen. Dr Wollaston's doublet was further improved by Mr Holland, who substituted two lenses for the first in Dr Wollaston's doublet, and retained the stop between them and the third. This combination, though generally



Fig. 2.

called a triplet, is virtually a doublet, inasmuch as the two lenses only accomplish what the anterior lens did, although with less precision, in Dr Wollaston's doublet. In this combination (fig. 3) of lenses the errors are still further reduced by the close approximation of the lenses to the object, which causes the refraction to take place near the axis, and thus we have a still larger pencil of light transmitted, and have also a more distinct and vivid image presented to the eye.

Simple Microscope.—By this term we mean an instrument by means of which we view the object through the lens directly. These instruments may be divided into two classes—those simply used in the hand, and those provided with a stand or frame, so arranged as to be capable of being adjusted by means of a screw to the exact focal distance, and of being moved over different parts of the object. The single lens used may be either a bi-convex or a plano-convex. When a higher power is wanted a doublet, such as we have already described, may



Fig. 4.

be employed, or a Coddington lens, which consists (fig. 4) of a sphere in which a groove is cut and filled up with opaque matter. This is perhaps the most convenient hand lens, as it matters little, from its spherical form, in what position it is held. In the simple microscope single or combined lenses may be employed, varying from a quarter to two inches. There are many different kinds of stands for simple microscopes made, but, as they are principally used for dissection, the most important point next to good glasses is to secure a firm, large stage for supporting the objects under examination. When low powers alone are used the stage-movements may be dispensed with; but when the doublet or triplet is employed some more delicate adjustment than that of the hand is necessary.

Compound Microscope.—In the compound microscope in its simplest form the observer does not view the object directly, but an inverted real image or picture of the object is formed by one lens or set of lenses, and that image is looked at through another lens. The compound microscope consists of two lenses, an object and an eye lens; but each of these may be compounded of several lenses playing the part of one, as in the simple microscope. The eye-lens, or ocular, is that placed next the eye, and the object-lens, or objective, that next the object. The objective is generally made of two or three achromatic lenses, while the eye-piece generally consists of two plano-convex lenses, with their flat faces next the eye, and separated at half the sum of their focal lengths, with a diaphragm or stop between them. Lenses of high power are so small as to admit only a very small beam of light, and consequently what is gained in magnifying power is often worthless from deficient illumination. Various devices have been employed to overcome this difficulty. The light may be concentrated by achromatic condensers placed beneath the stage, or the curvature of the lens may be such as to allow as large a number of divergent rays as possible to impinge upon it. Such a lens is said to have a large 'angle of aperture,' the angle of aperture being that made by two lines converging from the margins of the lens to its focal point. Recently lenses, termed 'immersion lenses,' have been constructed, of such a curvature that when immersed in a drop of liquid placed over the object light is admitted on all sides. With an immersion lens there is high magnifying power with sufficient illumination.

The accompanying diagram (fig. 5) explains the manner in which the complete compound microscope acts. We have here represented the triple achromatic objective, consisting of three achromatic lenses combined in one tube, in connection with the eye-piece, which now consists of the field-glass, FF, in addition to the eye-glass, EE. The function of the field-glass, FF, is that the rays of light from the object tend, after traversing the objective, to form an image at AA; but coming in contact with the field-glass, FF, they are bent, and made to converge at BB, where a real image is formed, at which place a stop or diaphragm is placed to intercept all light, except what is required to form a distinct



Fig. 3.

image. From BB the rays proceed to the eye-glass, EE, exactly as they do in the simple microscope. The real image formed at BB is therefore viewed as an original object through the eye-glass, EE. The lens, FF, is not essential to a compound microscope; but as it is quite evident that the rays proceeding to AA would fall exterior to the eye-lens, EE, if it were removed, and only a part of the object would thus be brought under view, it is always made use of in the compound microscope.

A mirror is placed under the stage for reflecting the light through the object under observation. This method of illumination by transmitted light is used when the object is transparent. When opaque, light is reflected on the object by a bull's-eye lens, called a condenser. The best instruments are supplied with six or seven object-glasses, varying in magnifying power from 20 to 2500 diameters. The eye-pieces supplied are three in number, each of which consists of two plano-convex lenses, between which a stop or diaphragm is placed, half-way between the two lenses. As the magnifying power of a compound microscope depends on the product of the magnifying powers of the object-glass and the eye-piece, it follows that its power may be increased or diminished by a change in either or both of these glasses. In the mechanical arrangements it is of importance to have the instrument so constructed that, while every facility is afforded for observation and easy adjustment, there should also be great steadiness. These ends are achieved in various ways, of which fig. 6 is one of the simplest: *a*, brass stand, supported on three feet; *b*, mirror supported on trunnions; *c*, diaphragm, pierced with circular holes of various sizes, to regulate the admission to the object of reflected light from the mirror; *d*, stage-plate, on which the object is placed; *e*, screw, with milled head for fine adjustment; *f*, the object-glass or objective; *g*, brass tube in which the body of the instrument is moved, so as to effect the coarse adjustment; *h*, the eye-piece, or ocular.

Morphine, or MORPHIA, $C_{17}H_{19}NO_5$, was the first alkaloid isolated in a pure state (by Sertürner, an apothecary, in Hanover in 1816). The name morphia was given to it in allusion to its crystalline form (Gr. *morphē*, 'form'). It is the most important of the alkaloids existing in opium, of which it usually constitutes from $\frac{1}{4}$ th to $\frac{1}{2}$ th by weight, and in which it is combined with meconic, sulphuric, and probably other acids. It is obtained as white, silky, translucent crystals, with a bitter taste and alkaline reaction. Morphine is soluble in about 1000 parts of cold and in 400 of boiling water; boiling alcohol dissolves it freely; but it is insoluble in pure ether and chloroform. Morphine is not so easily detected in cases of poisoning by opium as Meconic Acid (q.v.). The following are some of the ordinary tests for it: concentrated nitric acid added to morphine or any of its salts

gives an orange colour; when it is mixed with iodic acid iodine is liberated; in solution it gives a blue colour with persalts of iron.

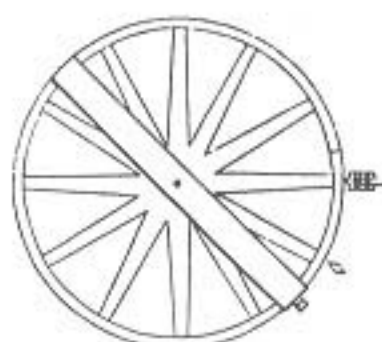
Morphine is the only opium alkaloid which is soluble in lime-water, and this property affords one of the best means of extracting it. A watery infusion of opium is boiled with milk of lime, filtered, mixed with powdered sal-ammoniac, and again boiled. By this means the lime is converted into the chloride of calcium, the ammonia is volatilised by the heat, while the morphine is precipitated in an impure form, which admits of easy purification.

Morphine combines with acids to form crystallisable salts, which are readily soluble in water and in alcohol. Of these, the hydrochlorate (muriate), the acetate, the bimeconate, and other salts are much used in medicine. Apomorphia, a white crystalline powder with physiological properties like those of morphia, is obtained by heating morphia with an excess of hydrochloric acid.

The therapeutic uses of morphine and its salts are very similar to those of Opium (q.v.), but morphine is employed largely in cases where Hypo-

dermic Injection (q.v.) is desired. The ordinary dose of morphine, or its salts, when given to an adult to allay pain or induce sleep, ranges from an eighth of a grain to half a grain. Many persons are addicted to the habitual use of morphine. The effects are very much the same as those of opium, and it is taken for the same reasons; but morphine is more rapid in action and more efficacious, and is not accompanied by some inconveniences which attend the use of opium. The habitual abuse has its origin in the legitimate use as a medicinal agent. But when the habit is established, the evil consequences soon set in, though some constitutions suffer much more than others. As a rule, *habitués* become pale, sallow, emaciated, appetite is diminished, digestion disordered, sleeplessness sets in, and defies extra doses of the drug. If, as is usual, the morphine is subcutaneously injected, all parts of the body within reach of the syringe may become one mass of sores, so that it is hard to find a place for a new injection. The will is enfeebled: the man or woman becomes a mere paralytic. A special hospital has been equipped in Paris for victims of this self-indulgence.

Mural Circle, an astronomical instrument for



Mural Circle.

the observation of celestial bodies at their meridian passage. It consists of a large metal circle, turning on an axis the end of which projects from a solid stone pier or wall (whence the name), close to which the circle moves. The plane of the circle is set as nearly as possible in the meridian. Fixed immovably to the circle is a telescope, which by turning the circle is made to point to the star to be observed, at the time of its meridian passage. Two wires, one fixed and one movable, similar to those in the Transit Circle (q.v.), enables the altitude, or zenith distance, of the star to be noted, if the instrument has been properly adjusted, and if the zenith or horizontal point on the circle be known. On the rim of the circle are divisions in degrees, &c., so that the angle through which it is turned can be noted by means of several microscopes, as in the transit circle. The mural circles once in use at Greenwich were six feet in diameter, and each degree of the division on the edge measured more than six-tenths of an inch in length. The manner of support allowed of a large circle, which gave this advantage. The mural circle is now almost obsolete, modern improvements enabling all its work to be much better done by the transit circle.

Muscle, the fleshy parts of an animal. Muscular tissue is specially distinguished by its power of contracting in one direction, and is the instrument by which all the sensible movements of the animal body are performed. When examined under a high magnifying power the fibres

of which it is composed are found to exist under two forms, which can be distinguished from one another by the presence or absence of very close and minute transverse bars or stripes. The fibres of the *voluntary* muscles—those whose movements can be influenced by nerve impulses originated by the will—as well as the fibres of the heart, are *striped*; while those of the *involuntary* muscles, such as the muscular fibres of the intestinal canal, of Blood-vessels (q.v.), and in skin, are *unstriped*.

On examining an ordinary voluntary muscle with the naked eye, we observe that it presents a fibrous appearance, and that the fibres are arranged with great regularity in the direction in which the muscle is to act or contract. On closer examination

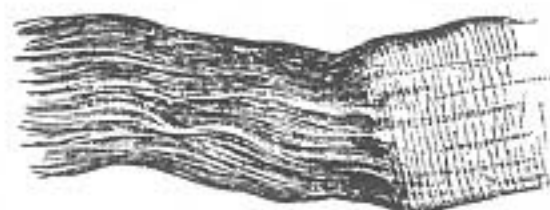


Fig. 1.—Attachment of Tendon to Muscular Fibre in the Skate.

it is found that these fibres are arranged in *fasciculi*, or bundles of various sizes, enclosed in sheaths of areolar tissue, by which they are at the same time connected with and isolated from those adjoining them;

and when the smallest *fasciculus* visible to the naked eye is examined with the microscope it is seen to consist of a number of cylindrical fibres lying in a parallel direction, and closely bound together. These fibres may end in blunt extremities or be forked as in the lips, or branched as in the tongue. Each fibre consists of an elastic homogeneous sheath—the *sarcolemma* (Gr. *sarx*, 'flesh,' and *lemma*, 'a skin or husk'), which contains a contractile semi-fluid material. This substance shows transverse striæ at regular intervals, as well as longitudinal striæ. Dilute mineral acids cause the fibre to cleave crosswise into discs. When highly magnified the transverse striæ resolve themselves into (1) a thin dim disc whose edges appear to adhere to the sarcolemma, (2) a clear space, (3) a broad dim disc, (4) a clear space like 2, (5) another disc like 1, &c.

Nerve fibres pierce the sarcolemma, and end upon the contractile substance (see NERVOUS SYSTEM). No blood-vessels penetrate the sarcolemma; they merely lie in the intervals between the fibres. Through the medium of tendon or aponeurosis the muscular fibres are attached to the parts which they are intended to move. Aggregated in parallel series, of greater or lesser size, and associated with nerves, vessels,



Fig. 3.—Muscular Fibre of Frog's Tongue—mag. 200 diameters (after Kölliker).

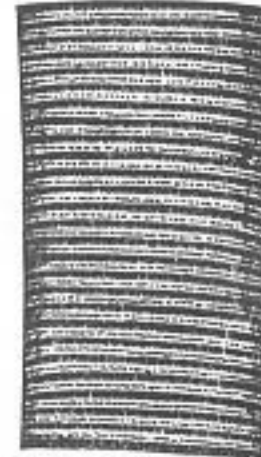


Fig. 4.—Portion of Human Muscular Fibre—mag. 600 diameters.

tendinous structures, &c., they form the various muscles, which are for the most part solid and elongated, but are sometimes expanded (as in the diaphragm) into a membranous shape. In the human subject voluntary muscles are red, and although pale fibres are scattered



Fig. 5. Muscular fibre-cells from the coat of the Small Intestine (after Quain): a, complete cell showing nucleus, intranuclear network and longitudinal fibrillation; b, cell broken in process of isolation.

through many of them, still nothing is ever seen to correspond with what may be found in the muscles of the rabbit. The colour is due to a substance closely akin to the blood-pigment. Each muscle has a middle portion or *belly* and two extremities which are attached. When the belly contracts it acts in a straight line, and drags equally on both extremities; but, as one is more fixed than the other, the force is spent in bringing the movable attachment nearer to the fixed one, and thus the fixed end is named the *origin*, the movable end the *insertion*. Muscles are usually grouped around joints, and attached to bone.

The *involuntary* or *unstriated* muscular tissue most commonly occurs in the shape of flattened bands of considerable length, but of a width not exceeding $\frac{1}{16}$ th or $\frac{1}{8}$ th of an inch. Their substance presents fine longitudinal markings, and each cell possesses an elongated nucleus, towards each end of which a few fine granules are found. Kölliker has shown that every one of these bands or fibres is either a single elongated cell (a fibre-cell) or a fasciculus of such cells (see CELL). These fibres have not usually fixed points of attachment like the striated fibres, but form continuous investments around cavities within the body, such as the intestinal canal, the blood-vessels; or are dispersed through the substance of tissues, such as the skin, to which they impart a contractile property.

Cardiac muscle, although involuntary, differs in a remarkable manner from the fibres just described. It consists of quadrangular cells, which are often branched at their ends. Each cell has a clear oval nucleus near its centre, and the cells present transverse striae not so distinct and less regular than those of voluntary muscle. Hitherto these cardiac fibres have not been shown to possess a sarcolemma.

The chemical composition of ordinary or voluntary muscle is described at FLESH. The fibrillae, or the sarcolemmas of which they are composed, consist of a substance termed Syntonin (q.v.), which closely resembles the fibrine or coagulating constituent of the blood; and the same syntonin is also the main constituent of the unstriated muscles, or at all events of their fibre-cells. Like the blood-fibrine, it exists in a fluid form in the living tissue, and only coagulates or solidifies after death.

Muscles vary extremely in their form. In the limbs they are usually of considerable length, surrounding the bones and forming an important protection to the joints; while in the trunk they are flattened and broad, and contribute very essentially to form the walls of the cavities which they enclose. Muscles derive their names variously (1) from their situation—as the temporal, pectorals, gluteals; or (2) from their direction—as the rectus, obliquus, &c., of which there may be several pairs—as, for example, rectus femoris, rectus capitis; or (3) from their uses—as the masseter, the various flexors, extensors; or (4) from their shape—as the deltoid, trapezius, rhomboid; or (5) from the number of their divisions—as the biceps and triceps; or (6) from their points of attachment—as the sterno-cleido-mastoid, the sterno-thyroid.

The skeleton, which may be termed the locomotive framework, may be regarded as a series of levers, of which the fulcrum is, for the most part, in a joint—viz. at one extremity of a bone—the re-

sistance (or weight) at the further end, and the force (or muscle) in the intermediate portion. In most cases, in order to preserve the necessary form of the body, muscles are applied at a great mechanical disadvantage as regards the exercise of their power; that is to say, a much larger force is employed than would suffice, if differently applied, to overcome the resistance. The two main sources of this disadvantage lie in the obliquity of the insertion, and consequently of the action of most muscles, and in the muscles being usually inserted very near the fulcrum. The first of these disadvantages is in many cases diminished by the enlargements of the bones at the joints. See fig. 8, A.

The tendons (i) of the muscles (m) situated above the joint are usually inserted immediately below the bony enlargement, and thus reach the bone that is to be moved (o) in a direction somewhat approaching the perpendicular. If this enlargement did not exist (as in fig. 8, B), the contraction of the muscle, instead of causing the lower bone to turn upon the upper one with comparatively little loss of power, would do little more than cause the two ends of the bones to press upon each other. The second mechanical disadvantage is compensated for by gain in the extent and velocity of movement, and by the avoidance of the great inconvenience of having the muscles extended in straight lines between the ends of jointed continuous levers. Thus, the bones of the forearm (fig. 9, b, c) are bent upon the bone of the arm (a) by the biceps muscle (d), which arises close to the head of the latter, and is inserted at e, at a short distance from the elbow-joint, which acts as the fulcrum of the lever (c). By this arrangement a contraction of a single inch in the muscle moves the hand (f), in the same time, through the extent of about 12 inches, but then the hand moves through every inch with only about the twelfth part of the power exerted by the muscle. By the junction of two or more levers in one direction, as in the different segments of the extremities, the extent and velocity of their united actions are communicated to the extreme one.



Fig. 7.—Muscular fibres from the Heart.

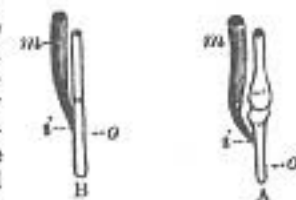


Fig. 8.

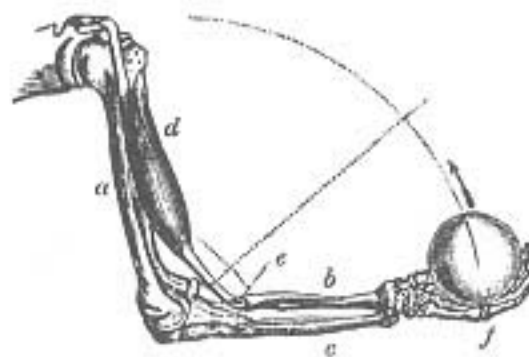


Fig. 9.

Thus, a blow of the fist may be made to include the force of all the muscles engaged in extending the shoulder, elbow, and wrist.

The great and characteristic property of muscular tissue—that of shortening itself in a particular direction when stimulated—is called *contractility*. The stimulus may be direct irritation by mechanical means, or by galvanism, or by some chemical substance, but in the living body the muscular fibres are, in most cases, made to contract by the immediate influence of the nerves distributed among them, which are consequently termed *motor nerves* (see NERVOUS SYSTEM), and are under the influence of the will. By an exertion of volition, we can contract more or fewer muscles at once, and to any degree, within certain limits; and, as a matter of fact, there is hardly any ordinary movement performed in which several muscles are not called

into play. But every voluntary muscle is also subject to other influences more powerful in their operation than the will. The movement of the features under the impulses of passion and emotion are more or less involuntary, as is shown by the very partial power the will has of restraining them, and the extreme difficulty of imitating them. Many movements ensue involuntarily when certain impressions, which need not necessarily be attended with consciousness, are made on the surface of the body, or on any part of its interior, either by external or internal causes. Such movements are termed *reflex*, and are noticed in the article NERVOUS SYSTEM.

Mushroom, or **AGARIC**, the popular name of a somewhat diverse group of genera and species of fungi belonging to the sub-order Hymenomycetes, of the great class Cryptogams. The best known of the true mushrooms to English readers is the Common Mushroom (*Agaricus campestris*), and it is the type of the sub-order named. In Britain it is the most esteemed of its tribe, though little valued in countries where fungi more generally form an article of diet of the people; in Italy it is disapproved. It should be noted that some of the forms common to Europe and North America are esteemed in England, but found unpalatable in the United States. The Common Mushroom varies considerably in appearance according to soil and locality, but presents in all its variations the same essential characters. It has a fleshy head or *pileus*, smooth or scaly on the upper surface, varying in colour from white to different shades of tawny or fuliginous brown. The gills (*hymenium*) on the under side of the head are free, at first pallid, changing by gradations in age to pink, purple, and brown-black. The stem is white, varied in shape, full, firm, furnished towards the top with a white persistent ring. The Common Mushroom is widely distributed in most of the temperate regions of both the northern and the southern hemispheres. In Britain it is abundant chiefly in autumn in pastures and orchards.—The Horse Mushroom (*A. arvensis*) is very frequently found growing in company with the Common Mushroom. It is altogether a coarser and larger form, and is less favoured for culinary purposes except in the making of ketchup. It often attains enormous dimensions; the top is generally smooth and snow-white, gills brownish white, ultimately with age becoming brown-black, stem pithy or hollow, with a ragged or floccose ring. This is the 'White-caps' Mushroom of some parts of England.—The true St George's Mushroom (*A. gambosus* of some, or *primulosus* of others), so called from appearing about St George's day (April 23), is sometimes confounded with the Common Mushroom. The head is thick and fleshy, at first convex, becoming undulated and irregular in outline, light yellow in colour in the centre, fading to opaque white at the edges, gills yellowish white, irregularly interposed, smaller and larger, overlying each other like the plaits of a frill; the stem is solid, white, when young bulging at the base, but in age either equal throughout or taper-



Fig. 1.

1. Parasol Agaric (*Agaricus procereus*); a, young. 2. Orange-milked Agaric (*A. delicatulus*); b, young. 3. White Field Agaric (*A. virginicus*); c, young.

ing to greater thickness above. The skin of this mushroom is soft and firm to the touch, and in

appearance has been aptly described by Berkeley as resembling a cracknel biscuit. It is one of the most prized of the Agarics on the Continent, so much so in Rome that a dish of it is considered the most fitting present to any one whose good offices are to be propitiated.—The Fairy-ring Mushroom (*A. oreades*; *Marasmius oreades* of some), also the Champignon of the French, is common in pastures and in lawns in Britain, and in most parts of Europe. The head is small, smooth, fleshy, convex, having a boss (umbo) in the centre, tough, leathery, elastic, wrinkled; when soaked with water brown, when dry buff. The gills are free, distant, somewhat paler than the head; the stem equal in thickness, twisted, tough, fibrous, of a pale silky-white colour. This species is much esteemed by all who know it. Its flavour is extremely fine, and it is employed in the making of the best kinds of ketchup. On the Continent it is dried and used in the form of a powder to flavour various made dishes. Its peculiar mode of growing in circular patches or in rings, which procured for it its popular name, leads to the risk of an allied but poisonous species which sometimes grows in the same manner being confounded with it. This is the False Champignon (*A. or Marasmius urens*), which is readily distinguished from the true Fairy-ring Mushroom by its having a flat top without any boss, and by its narrow gills being closely crowded together. The foregoing are the most commonly esteemed of edible British mushrooms. But there are a number of others which are not only wholesome but extremely delicate in flavour and nutritious. There is the Parasol Mushroom (*A. procerus*); the Maned Mushroom (*Coprinus comatus*), of which young specimens only should be used; the Red-fleshed Mushroom (*A. rubescens*); the Clouded Mushroom (*A. nebularis*), appearing late in autumn in moist places on the borders of woods; and the Orange-milk Mushroom (*Lactarius* or *A. deliciosus*). This last is much prized by connoisseurs in edible fungi on the Continent and in Britain. It has, as the name implies, orange-coloured milky sap in the head, and when broken or bruised both the flesh and the milk become green by exposure to the air. This is an



Fig. 2.

4. St George's Agaric (*Agaricus georgii*); d, young. 5. Common Mushroom (*A. campestris*); e, young. 6. Fairy-ring Mushroom (*A. oreades*); f, young. 7. *Clavaria phalloides*; g, young.

excellent test when there is any doubt as to the identity of this and an allied but virulently poisonous species—*L. torminosus*—in which both the flesh and the milk are white, and do not change colour when broken or bruised. Although many of the British fungi are wholesome and nutritious food, yet it is proper that the inexperienced in diagnosing them should be cautioned strongly against eating any species of the wholesome qualities of which they are not absolutely assured. In many continental cities inspectors are appointed to examine all fungi that are brought to market, lest deleterious species should perchance be sold to the people.

Naphtha is derived from the Persian word *nafata*, 'to exude,' and was originally applied to liquid hydrocarbons which exude from the ground in the neighbourhood of the Caspian Sea; in like manner it was applied to the natural oils found more or less plentifully in nearly all countries of

the world, and also to the oil distilled from Bog-head mineral in Scotland. But the inconvenience and danger of classing all these oils indiscriminately as naphthas became apparent after the Scotch paraffin and the American petroleum refined oils began to be used for domestic illumination. The word naphtha is still used in a very general and vague sense, and has no specific application either scientifically or commercially to any particular liquid; but since the more general application of the words paraffin and petroleum to mineral oils the sense in which the word naphtha is used has been narrowed considerably. The various British Petroleum Acts since 1862 have also aided in the interest of public safety in emphasising the wise distinction now made between the heavier and safe hydrocarbon oils on the one hand, and the volatile and unsafe hydrocarbon spirits or naphthas on the other.

Commercially, naphtha is now understood to apply to the inflammable distillates of crude mineral oils and coal-tar. For trade convenience the volatile distillates of petroleum and shale oil are known respectively as petroleum spirit and shale spirit, to distinguish each from the other, and both from coal-tar naphtha. The term naphtha also embraces distillates of india-rubber, bones, peat, and wood, the last of these being known as wood-spirit or methyl alcohol. A few words with regard to each of these naphthas may serve to indicate more particularly the nature and method of production, and also the uses to which they are applied.

Petroleum spirit is obtained from crude petroleum in the process of refinement by distillation. The first or lightest portion of the oil which passes over from the still, being highly inflammable, is not allowed to mix with the burning oil, but is run into a separate or naphtha tank. American crude petroleum yields from 15 to 20 per cent. of crude naphtha, which in some of the refineries is separated into gasoline, sp. gr. '640 to '650; benzine, sp. gr. '670 to '710; and benzoline or deodorised spirit, sp. gr. '710 to '730. Russian crude petroleum yields a comparatively small proportion of naphtha, about 5 or 6 per cent., which is separated into light benzine and heavy benzine, varying in sp. gr. from '730 to '775. Shale spirit is a product of the crude oil distilled from shale, which is one of the important mining and chemical industries of Scotland. This crude oil contains 4 to 5 per cent. of naphtha, having a sp. gr. of '715 to '740; but some of the shale-oil works produce a small quantity of gasoline with a sp. gr. of '640 to '680. Coal-tar naphtha is distilled from the tar obtained from coal in gas-works. The production of tar is 10 to 12 gallons per ton of coal put through the retorts. This tar on distillation yields from 5 to 20 per cent. of naphtha according to the quality of coal used. Gas-tar from Newcastle coal gives only 5 per cent. of naphtha, while the tar from some cannel coals yields as much as 20 per cent. Coal-tar naphtha has a sp. gr. varying from '850 to '950, and is thus much heavier than the naphthas obtained from crude mineral oils. Coal-tar naphtha may be fractionated into a variety of hydrocarbons with boiling-points ranging from 175° to 350°; but the two of the greatest commercial importance are benzole and ordinary naphtha. Caoutchouc is a naphtha obtained by the destructive distillation of caoutchouc or india-rubber. It also may be fractionated into a number of hydrocarbons of different densities and boiling-points. Bone-naphtha is obtained by the distillation of bones in the manufacture of animal charcoal. It is known also as bone-oil, or Dippel's animal oil. Owing to some neutral or nitrogenous substance as yet unknown, it possesses a peculiarly offensive smell, and until some easy means is discovered of removing this very objectionable feature bone-oil can never become of much use as a naphtha. The crude naphthas obtained from these various sources are all refined or purified by similar processes—viz. simple redistillation by means of steam, as in America, for the lightest fractions; but for the heavier spirits a treatment with sulphuric acid and then with caustic soda, and a subsequent washing with water are necessary previous to redistillation.

The uses to which in the industrial arts the different qualities of naphtha are applied are very numerous. The lighter spirits, such as benzole and benzine, being solvents of grease and oil, are used for detergent purposes. Benzoline was for some years burned pretty generally by the poorer classes

in cheap benzoline or sponge lamps; but its use in this way has happily been greatly restricted, if not quite superseded, by the low price at which petroleum and paraffin oils have for some years been obtainable. The light naphthas are also used for extracting the perfumes of flowers and plants, and the oil from various seeds. Gasoline is employed exclusively for carburetting air-gas. The bulk of the coal-tar naphtha, and much of the shale and petroleum spirit, are employed as solvents in the manufacture of india-rubber and gutta-percha goods. They are also solvents of wax, and fatty and resinous bodies generally, and are so used in refining the best qualities of paraffin wax. Large quantities are consumed in naphtha, torch, and other flaring lamps for outside use. They are also used as a substitute for turpentine in the preparation of paints; and in Scotland the solvent action of shale spirit is turned to account in the preparation of an anti-damp or stone- and timber-preserving fluid called Alexinton. A considerable percentage of paraffin wax is dissolved and held in solution by the spirit; and if this liquid be applied to freestone, brick, or wood, it passes into the pores of the material, and the spirit rapidly evaporating leaves the wax permanently in the stone or wood, so that water cannot be absorbed by it. While for these various purposes all the naphthas produced in Britain find a ready market, in America and Russia petroleum spirit is made in such quantities that it is impossible to find profitable outlets for it all; and although large quantities in many petroleum refineries are consumed as fuel under the stills, yet much of the crude naphtha has to be burned in waste pits to get rid of it.

Naphthalene, $C_{10}H_8$, is a solid substance obtained from Coal-tar (q.v.). It forms thin, transparent, brilliant plates with a pearly lustre and unctuous to the touch. It melts at 176° (80° C.) and boils at 422° (217° C.), but it readily sublimes at a much lower temperature. Although not very inflammable, it is used (as in the Albo-carbon light) to increase the illuminating power of coal-gas, the naphthalene being placed in a metal receiver heated by the gas-flame, and the illuminating gas passed slowly through. A smoky but brilliant light is thus obtained which under some circumstances may be useful. Naphthalene is of most importance from a scientific standpoint. Its molecule of $C_{10}H_8$ may be regarded as made up of two aromatic nuclei, having two atoms of carbon in common; but for further information on this point, see AROMATIC SERIES. Naphthalene forms an extensive series of derivatives in which one or more atoms of hydrogen are replaced by NO_2 —chlorine, bromine, &c.

Narcotics (Gr. *narkē*, 'stupor') are remedies which produce stupor if the dose be increased beyond a certain point. Opium is the most important member of the group, and the type from which most descriptions of the action of this class of medicines have been drawn; but it includes substances of very various properties. Some, as alcohol, produce intoxication in lesser doses; some, as belladonna, delirium; most have a primary stimulating effect: in fact, almost every one presents some peculiarity in the way in which it affects the system, and no satisfactory general description of their minor effects is possible. Their power of inducing sleep has procured for them the names of Hypnotics and Soporifics; while many of them are termed Anodynes, from their possessing the property of alleviating pain. Next to opium, Henbane, Indian Hemp, and Chloral may be regarded as the most important narcotics. Numerous artificially-produced organic compounds have been introduced during the last few years, some of which (e.g. paraldehyde, sulphonal as hypnotics; antipyrin, exalgin—an aniline derivative—as anodynes) will probably take a permanent place among useful remedies.

Narcotics are usually administered either with the view of inducing sleep or of alleviating pain or spasm. As, however, their action is much modified by a variety of circumstances—such as age, idiosyncrasy, and prolonged use—they should be administered with extreme caution, and, as a general rule, only under competent advice. The various quack medicines for children which are known as *Carminatives*, *Soothing Syrups*, &c. almost always contain some form of opium, and are a fertile cause of the great mortality that occurs in early life, especially among the poorer classes. All the narcotics when taken in excess are poisonous (see POISONS).

Narcotine ($C_{17}H_{23}NO_7$) is one of the organic bases or alkaloids occurring in opium, in which it usually exists in the proportion of 6 or 8 per cent. It is nearly insoluble in water, but dissolves sparingly in alcohol, readily in chloroform and ether. Narcotine possesses very slight alkaline properties; its salts do not readily crystallise, and are even more bitter than those of morphia, although the substance itself is almost tasteless. When first discovered (in 1803) it was supposed to be the stimulant principle of opium; but in reality it possesses very little activity. Its sulphate has been used in India as a substitute for quinine. Narcotine yields a great variety of compounds by decomposition, perhaps the most interesting being vanillin, the flavouring principle of vanilla.

Nervous System, the mechanism by which an animal acquires a knowledge of the external world, and by means of which the great functions of the absorption of food, the elimination of waste products from the body, the respiration, circulation, and muscular action, are regulated and controlled. In its simplest form, in some of the lowest animals, it consists merely of nerve-fibres going to and from a small group of nerve-cells; but from this elementary condition there is an ever-increasing degree of complexity till its highest development is reached in man, which alone is included in the following description. In the articles on Birds, Fishes, Reptiles, Mollusca, &c. will be found paragraphs on the nervous systems of the various classes of animals.

The nervous system is composed of a series of organs—nerve-cells, nerve-fibres, and nerve end-organs. The nerve-cells are situated for the most part in the brain and spinal cord, but also in other parts of the nervous system. Their function is either to receive, to send out, or to modify as they transmit, nervous impulses. The nerve-fibres transmit nerve impulses to and from the nerve-cells. For this reason groups of nerve-cells are often conveniently spoken of as nerve centres; their relation to the nerve-fibres being analogous to that of a telegraph-office to the wires connected with it. The end-organs are the special structures for receiving impressions, such as the various organs of special sense, smell, sight, hearing, taste, touch (see NOSE, EYE, EAR, TASTE, TOUCH), and for transforming outgoing impulses into muscular contractions or secretion, &c. The nerve-fibres thus connect either an end-organ with a nerve centre, or two nerve centres with each other. These three sets of organs—nerve centres, fibres, and end-organs, are grouped into two great systems—the *cerebro-spinal* (fig. 1) and the *sympathetic* (fig. 10) system. The former is composed of the brain, spinal cord, and the cranial and spinal nerves respectively connected with them. The sympathetic system is formed by a double chain of small swellings, called ganglia, on either side of the front of the spinal column, and connected with each other, with the spinal nerves, and the internal organs by fine nerve-fibres (figs. 7 and 10).

The nerves are whitish cords varying greatly in size. They are composed of nerve-fibres which are bound together by fibrous tissue. This forms a sheath on the outside (the *perineurium*), and sends processes inwards between the individual nerve-fibres (fig. 4 shows a transverse section of part of a nerve, with the bundles of connective tissue passing inward). In the spinal cord and brain the nerve-fibres are held together by a special kind of connective tissue, called *neuroglia*.

Structure of Nerve-fibres.—A fibre from a spinal nerve has the following structure. In the centre is a very fine fibre or thread called the *axis cylinder*. This runs without any interruption along the whole length of the nerve. It can be traced into a nerve-cell at one extremity, and into an end-organ at the other; and there is reason to believe that it is really an outgrowth from a nerve-cell. It is the essential constituent of a nerve, that namely along which the nervous impulse travels. The axis cylinder is in its turn composed of still finer fibrillæ, which may break up into finer nerve-fibres. Except at its origin and termination, the axis cylinder is covered by a tubular membrane called the *medullary sheath*, or the white substance of Schwann, a whitish substance of a peculiar fatty nature. This is interrupted at intervals of about $\frac{1}{2}$ th of an inch by constrictions which (fig. 2) pass completely through its thickness. When a nerve is stained with nitrate of silver, a black

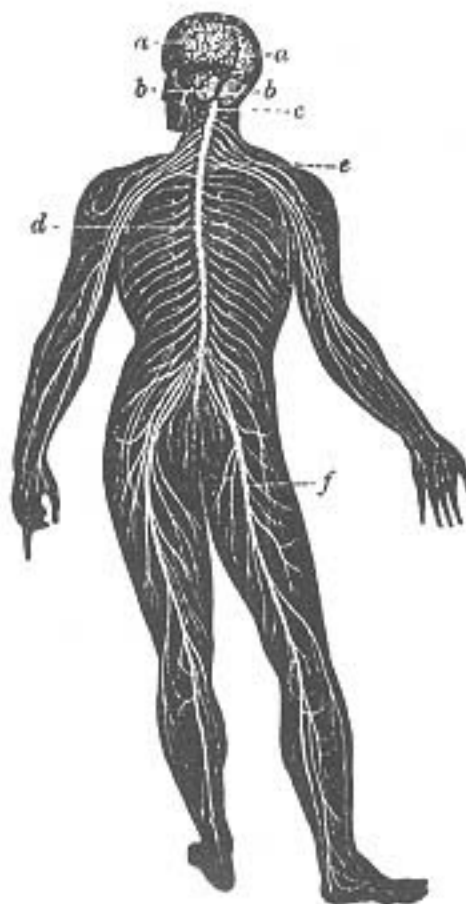


Fig. 1.

a, cerebrum; b, cerebellum; c, medulla oblongata; d, spinal cord, from which the spinal nerves arise; e, brachial plexus; f, sciatic nerve.

colour is formed at the intersections, and for a short distance along the axis cylinder (see fig. 3, where two are represented). These interruptions are called *nodes of Ranvier*, after their discoverer, and are supposed to allow of the percolation of lymph to nourish the axis cylinder. When a nerve



Fig. 2.

Small part of a nerve-fibre with axis cylinder, surrounded by medullary sheath. The primitive sheath passes over the constriction in the medullary sheath.

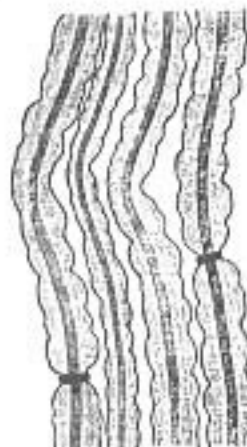


Fig. 3.

Nerve-fibres, stained with nitrate of silver, showing two nodes of Ranvier.

is divided transversely, and stained appropriately; the axis cylinder appears as a small point surrounded by a ring of the whitish medullary sheath

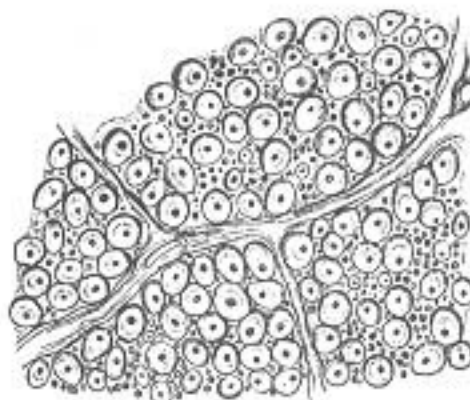


Fig. 4.

(fig. 4). This sheath is enclosed by a continuous investment, the *primitive sheath*. This is colourless, and very delicate, and has a nucleus on its inner side corresponding to each segment of the

medullary sheath. In the sympathetic system the medullary sheath is absent; while the fibres of the brain and spinal cord retain the medullary sheath,

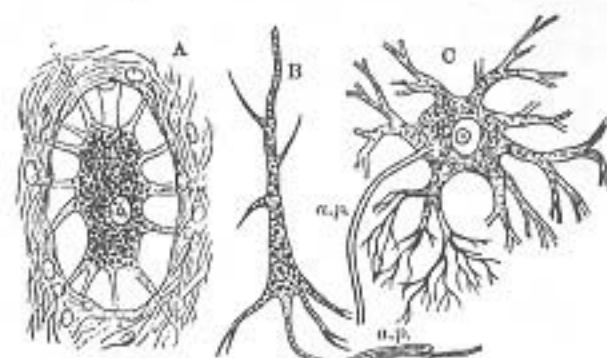


Fig. 5.—Nerve-cells:

A, from sympathetic ganglion; B, from cerebrum; C, from spinal cord; a.p., axis cylinder process.

but want the primitive membrane. The sympathetic fibres are often called *gray* or *non-medullated*; the others, white or *medullated*. The nerve-fibres in the limbs are about $\frac{1}{10}$ th of an inch in diameter; in the brain they may be nearly ten times finer.

The nerve-cells vary greatly in size and in form. Many of them, especially in certain regions of the cortex of the brain, have the shape of an elongated pyramid (fig. 5, B), with fine processes coming off at various points, others are very irregular in outline, but also with numerous processes, one of which can frequently be traced into continuity with a medullated nerve, and hence is called the *axis cylinder process*, while the others form a fine network before entering another cell or fibre. Such cells are called *multipolar* (fig. 5, A and C), and are seen best in the anterior horns of the gray matter of the spinal cord. Many cells, again, are *bipolar*—i.e. they have only two fibres, one at each pole, in connection with them.

The various end-organs are described under the



Fig. 6.

special sections. Fig. 6 shows the manner in which the fibres of a nerve end in a muscle.

The nerves arising from the brain are arranged in twelve pairs. The first, or olfactory, is the nerve of smell. The second, or optic, is the nerve of sight. It arises from the retina, meets with its fellow in the optic chiasma, and is distributed half to each side of the brain, terminating partly in the corpora quadrigemina (for the reflex movements of the eye), and partly in the optic thalamus, passing thence to the occipital lobe of the cerebrum (for the sense of sight). The third or oculo-motor nerve arises under the corpora quadrigemina, and passes to all the muscles of the eye except two, which are supplied by the fourth and sixth pairs. The fourth nerve, arising immediately behind the third nerve, supplies the superior oblique muscle of the eye; while the sixth pair, arising from a nucleus near the middle of the floor of the fourth ventricle, supplies the external rectus muscle of the eye. The fifth pair has a very long origin from a point at the level of the third nerve down to the upper part of the spinal cord. It is the motor nerve to the muscles of mastication, and the sensory nerve to the face, front of the head, teeth, tongue, and is the nerve of taste of the anterior part of the tongue. It is this nerve which is concerned in neuralgia of the head and face and teeth. The seventh pair arises from the lower part of the pons Varolii (see BRAIN), and is the motor nerve to the facial muscles of expression. Injury to or disease of this nerve causes facial palsy, or Bell's paralysis. The eighth pair, or auditory nerve, supplies the internal ear. It is divided into two parts, one of which supplies the cochlea, and is the nerve of hearing proper, while the other supplies the semi-circular canals, and is concerned in the maintenance of the equilibrium of the body. The nerve arises from the lateral and posterior part of the pons Varolii and medulla oblongata. The ninth pair, or glosso-pharyngeal nerve, is the special nerve of taste, and supplies the hinder third of the tongue, with the taste bulbs of which it is

connected. The tenth pair, or pneumogastric nerve, has a very wide area of distribution to the lungs, heart, stomach, &c.; it is partly motor and partly sensory in function. The eleventh pair, or spinal accessory nerve, is the motor nerve to the larynx, and to certain muscles in the upper part of the neck. These three nerves arise from a groove in the side of the medulla oblongata and upper part of the spinal cord. The twelfth pair, or hypoglossal nerve, is the motor nerve of the tongue. Its origin is near the floor of the fourth ventricle, close to the middle line, and it emerges from the anterior surface of the medulla oblongata in a shallow groove between the anterior pyramids and the inferior olivary body (see BRAIN).

The spinal nerves arise from the spinal cord in pairs, thirty-one in number, and are named according to their relation to the vertebrae—cervical, dorsal, lumbar, and sacral. Their mode of origin will be understood from fig. 7, which represents diagrammatically the first part of their course, and on one side their relations with the sympathetic system—C 1-8 represents the eight pairs of cervical nerves; D 1-12, the twelve dorsal pairs; L 1-5, the five lumbar pairs; and S 1-6, the six sacral pairs of nerves. Each spinal nerve arises by two roots, an anterior and a posterior (fig. 8, *a* and *p*; see also SPINAL CORD). These roots pass outwards, and unite before they leave the spinal canal. Before their union a small oval swelling is found on the posterior root, and is called its *ganglion*, *g*. The united nerve leaves the spinal canal by a small aperture between adjacent vertebrae. It almost immediately gives off a fine medullated nerve to its corresponding sympathetic ganglion, a branch which can be traced into one of the internal



Fig. 7.

organs. It also receives from the ganglion a non-medullated or gray fibre, which is distributed to the muscular coat of the blood-vessels, especially the arteries. The nerve thus altered passes outwards, dividing as it goes to send its ultimate branches into the fibres of the muscles, into the cells of the skin and connective tissues, tendons, and bones. In the dorsal region each nerve passes to its distribution without entering into connection with its neighbours, but in the cervical, lumbar,



Fig. 8.

and sacral regions the nerves split up and form new junctions with each other, or *plexuses* as they are called. (These are indicated in fig. 1, and on the right-hand side of fig. 7, but the detailed description of them is impossible within the limits of this article.)

Functions of the Spinal Nerves.—Sir Charles Bell discovered that division of the anterior roots was followed by loss of power of voluntary motion, and that division of the posterior roots destroyed the power of sensation. He termed the anterior root motor, and the posterior sensory. It has since been ascertained that the anterior roots carry outwards other impulses that do not result in motion, and that the posterior roots carry inwards impulses which may not result in sensation. Therefore, it is more correct to term these roots respectively *efferent* and *afferent*. If the anterior root be divided between the point of its origin from the cells of the anterior horn of the spinal cord and its junction with the posterior root, the part unconnected with the cord will waste along the whole length of the nerve, and the muscles which it supplies will waste also. The cells in connection with the anterior roots, therefore, not only send out motor impulses, but exert a nutritive or *trophic* influence on the

nerve and muscle. Division of the posterior root beyond its ganglion is followed by wasting of the corresponding fibres of the nerve to their ultimate termination. If the root be cut between the ganglion and the spinal cord, the part attached to the ganglion remains unaltered, while that connected with the spinal cord wastes. This shows that the ganglion of the posterior root exerts a trophic influence on the fibres connected with it. If the nerve be divided after the junction of the two roots, the whole of the nerve farthest from the spinal cord will waste.

The afferent nerve impulses which pass along the posterior roots comprise those which give rise to the sense of touch, pain, and temperature, and to reflex movements of various kinds without necessarily exciting our consciousness, such as those concerned with the maintenance of the equilibrium of the body, and with the functions of the internal organs.

Reflex Action.—By this we mean an action brought about directly by the influence of an afferent impulse quite independently of voluntary control. For such an action four elements are necessary: (1) afferent fibres, (2) nerve cells or centres, (3) efferent fibres, (4) muscle fibres. The impulse travels up the afferent fibres and stimulates the nerve-cells to send an impulse along the efferent fibre to the muscles. If any of these four factors is absent, the reflex action cannot take place. A familiar example is the moving of the foot as the result of tickling the sole. The afferent impulse passes up the nerves to the nerve centres in the spinal cord, which send outwards direct to the muscles motor impulses, which often cannot be controlled by the will.

Automatic Action.—When movement is brought about by an impulse originated in a nerve centre itself, without the influence of an afferent stimulus, it is called automatic or spontaneous. Such actions are apt to occur rhythmically, such as the action of the heart.

Voluntary Actions.—In these the outgoing impulses originate in the nerve-cells in the motor area of the brain, and pass down the opposite side of the spinal cord to the nerve-cells in its anterior horn. From thence they are transmitted by the efferent nerves to the muscles. Fig. 9 will explain the relation of voluntary to reflex action: *c* is a nerve-cell in the brain; *n*, the nerve-fibre in the spinal cord which transmits the nerve impulse originating in *c* to *s*, a cell in the anterior horn of the spinal cord which forwards it through a nerve, *e*, to a muscle, *m*. The reflex arc is represented by *a*, an end-organ; *a*, an afferent nerve; *s*, a nerve-cell; *e*, an efferent fibre; *m*, a muscle. If *c* or *n*, or both, be destroyed by disease, the power of voluntary motion will be lost, but the reflex arc, *a*, *s*, *e*, *m*, remains intact. We can sometimes control or repress a reflex action voluntarily. The cell *c* in the brain can so act on the cell *s* as to hinder or inhibit its ordinary response to a stimulus, and when the cell in the brain is destroyed the cell *s* is more easily stimulated reflexly, apparently because some restraining influence is removed. Such a restraining action is exerted on the heart by the pneumogastric nerve, which, when stimulated, slows or stops its movements; and in the same way the secretion of glands may be interfered with by abnormal stimulation of their nerve centres. This influence is termed inhibitory action, and is one of great importance.

Secretory Nerves.—The nerves which induce the various acts of secretion leave by the motor cranial nerves, or by the anterior roots of the spinal nerves; but the description of their distribution, &c. must be relegated to the article SECRETION.

The *sympathetic system* is, as already stated, composed of a series of ganglia situated on either side of the spinal column along its whole length. In the dorsal, lumbar, and sacral regions the ganglia correspond in number to the vertebrae; but in the cervical region there are only three, of such large size, however, that they are generally supposed to represent the fusion of a number of ganglia. Below, the two chains unite in front of the coccyx

in a single ganglion. These ganglia are formed of multipolar nerve-cells (fig. 5, *A*), and are united with each other by gray nerve-fibres. Each ganglion gives to its corresponding spinal (or cranial) nerve a gray non-medullated nerve, and receives from it a fine white medullated nerve. The fibres of distribution may be studied in fig. 10.

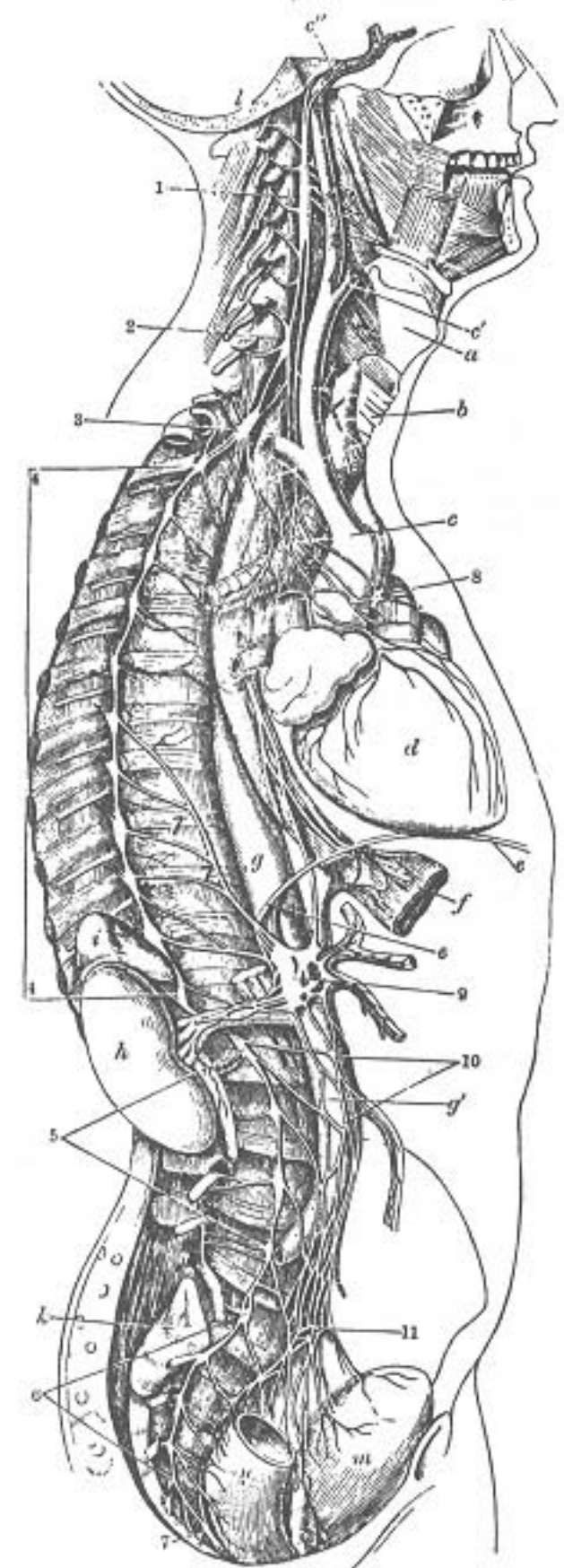


Fig. 10.—The Sympathetic Nerve; the right lateral walls of the chest and abdomen, and the stomach, intestines, liver, spleen, and pancreas being removed to bring it in view:

1, 2, 3, the superior, middle, and inferior cervical ganglia; 4, the two lines from this figure include the twelve dorsal ganglia; 5, include the four lumbar ganglia; 6, include the five sacral ganglia; 7, the ganglion impar; 8, cardiac plexus; 9, solar plexus; 10, aortic plexus; 11, hypogastric plexus; a, the larynx; b, the trachea; c, arch of the aorta; c', external carotid; c'', internal carotid; d, the heart; e, e, the diaphragm; f, the cardiac end of the oesophagus; g, thoracic, and g', abdominal aorta; h, the kidney; i, the supra-renal capsule; k, the sacrum; l, the section of base of the skull; m, the bladder; n, the lower portion of the rectum.

They pass to the blood-vessels and to the mucous membranes and muscular coats of the various internal viscera, and become united with each other in fine networks or plexuses, on many of which nerve-cells or ganglia are situated.

The sympathetic chain is continued upwards as a fine plexus of nerves on the internal carotid artery, on the various branches of which it is distributed. From the superior cervical ganglion also fibres pass to the various arteries in the neck and face, and to form, along with the pneumogastric and glosso-pharyngeal nerves, the pharyngeal plexus on the muscles and mucous membrane of the pharynx.

From some of the cervical and upper thoracic ganglia fibres pass into the chest, to form also, along with the pneumogastric nerve, two important plexuses, named pulmonary and cardiac, from which branches pass to the lungs and heart, and undoubtedly influence their functions. From the thoracic ganglia also arise the three splanchnic nerves which pass into the abdomen to enter the solar or epigastric and the renal plexus. The solar plexus is situated at the pit of the stomach, and is connected with two large semilunar ganglia, which send branches to all the blood-vessels and to all the organs within the abdomen. It is owing to the relations and functions of the solar plexus that blows in this region are so dangerous. The hypogastric plexus arises from the lumbar ganglia, and sends branches to the blood-vessels and to the organs in the lower part of the abdominal cavity, more especially the organs of generation, the lower bowel, and the bladder.

The functions of the sympathetic system are still imperfectly understood. It supplies fibres to the muscles of blood-vessels to regulate their calibre; hence these fibres are called *vaso-motor*. The vaso-motor centre is situated, not in the sympathetic system, but in the medulla oblongata. The path for the fibres passes down the spinal cord, which it leaves by the anterior roots at various levels to pass along the white communicating branches into the sympathetic ganglia. From these ganglia the vaso-motor nerves for the internal organs pass into the various plexuses just described, while those for the vessels of the limbs and trunk return to the spinal nerve by the gray communicating nerve. Further, the muscular movements and secretions of all the internal organs are regulated through the sympathetic system.

Of the nature of nerve energy we know little. The nervous impulse travels along a nerve in man at a rate of about 34 yards per second, and it is accompanied by certain electrical changes in the nerve, but nerve energy is not identical with electrical energy. It is probably accompanied by molecular changes in the structure of the nerve as yet inaccessible to our means of investigation. In like manner the origination or discharge of nerve impulse in a cell is probably induced by similar but more active changes in its substance.

Nicotine, $C_{10}H_{14}N_2$, is a volatile liquid alkaloid, and constitutes the active principle of the tobacco-plant, in all parts of which it occurs in combination with malic and citric acids. It is likewise contained in minute amount in the smoke of the burning leaves. When pure and freshly prepared it is a colourless, intensely poisonous liquid, which evolves a very irritating odour of tobacco, but on exposure to the air it rapidly oxidises and becomes brown in colour. It is moderately soluble in water, and dissolves readily in alcohol and ether. The quantity of nicotine in tobacco varies from 2 to 8 per cent.; the coarser kinds contain the larger quantity, while the best Havana cigars seldom have more than 2 per cent., and often less. Locally, nicotine is very irritating. Taken internally, it is one of the most powerful poisons known; $\frac{1}{2}$ grain taken by the mouth has caused in man distinct symptoms of poisoning, there being first seen a short stage of excitement, followed by headache, vertigo, great weakness, and general depression. Larger doses ($\frac{1}{2}$ grain) caused in addition trembling, vomiting, collapse, and great depression of the heart and respiration. A single drop is sufficient to kill a rabbit or cat in a few minutes. It has been used rarely for homicidal and suicidal purposes, but the minimum lethal dose in man is not accurately known.

Nitre, or **SALTPETRE** (Lat. *sal petrae*, 'salt of the rock,' through Old French), is the nitrate of potash, KNO_3 . It usually occurs in long, colourless, striated, six-sided prisms; its taste is cooling, and very saline; it is soluble in seven times its weight of water at 60° (15.5° C.), and in less than one-third of its weight of boiling water, but is insoluble in alcohol. When heated to about 660°

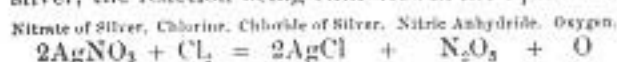
(348° C.) it fuses without decomposition into a thin liquid, which, when cast in moulds, solidifies into a white, fibrous, translucent mass, known as *sal prunelle*. At a higher temperature part of the oxygen is evolved, and nitrate of potash is formed. Owing to the facility with which nitre parts with its oxygen, it is much employed as an oxidising agent. Mixtures of nitre and carbon, or of nitre and sulphur, or of nitre, carbon, and sulphur, delagate on the application of heat with great energy; and if nitre be thrown on glowing coals it produces a brisk scintillation. *Touch-paper* is formed by dipping paper in a solution of nitre, and drying it.

Nitre occurs as a natural product in India and Persia, where it is found sometimes as an efflorescence upon the soil, and sometimes disseminated through its upper stratum. The crude salt is obtained by lixiviating the soil, and allowing the solution to crystallise. Much nitre used to be artificially formed in Europe by imitating the conditions under which it is naturally produced. Animal matter, mingled with ashes and lime rubbish, is placed in loosely aggregated heaps, exposed to the air, but sheltered from rain. The heaps are watered from time to time with urine or stable runnings; at suitable intervals the earth is lixiviated, and the salt crystallised. As there is always a considerable quantity of the nitrates of lime and magnesia present, which will not crystallise, carbonate of potash, in the shape of wood-ashes, is added so long as any precipitate occurs. The nitrate of lime is decomposed, and the insoluble carbonate of lime separated. The clear liquor is then evaporated and crystallised. But the bulk of the nitre of commerce is now made from the Chilean nitrate of soda by double decomposition. The common varieties of Indian nitre, which have a dirty yellowish appearance, are termed *rough* or *crude saltpetre*, while the purer kinds are called *East India refined*. The purification or refining of nitre is effected by dissolving it in water, boiling the solution, removing the scum, straining it while hot, and setting it aside to crystallise. The most common impurities are sulphate of potash, chlorides of sodium and potassium, and nitrate of lime. Chloride of barium will detect the first of these impurities, nitrate of silver the second, and oxalate of ammonia the third.

Nitre is employed in the manufacture of sulphuric acid, in the preparation of nitric acid, as an oxidising agent in numerous chemical processes, as an ingredient of fireworks, and especially in the manufacture of gunpowder. It is used in medicine. In moderate doses (from ten grains to a scruple) it acts as a refrigerant, diuretic, and diaphoretic, and hence its use is indicated when we wish to diminish abnormal heat, and to reduce the action of the pulse, as in febrile disorders and hemorrhages. In acute rheumatism it is given in large doses with great benefit. It is a popular remedy in sore throat, in the form of nitre balls, which should be retained in the mouth till it melts, and the saliva impregnated with it gently swallowed. The inhalation of the fumes produced by the ignition of *touch-paper* often gives speedy relief in cases of spasmodic asthma.

Cubic Nitre, or **Nitrate of Soda**, $NaNO_3$, occurs abundantly on the surface of the soil in Chili and Peru (especially Atacama and Tarapacá). It derives its name from its crystallising in cube-like rhombohedrons. In most of its properties it resembles ordinary nitre, but, in consequence of its greater deliquescence, it cannot be substituted for that salt in the preparation of gunpowder. Being considerably cheaper than the potash-salt, cubic nitre is often substituted for it in the manufacture of nitric and sulphuric acids; and it is largely used in agriculture.

Nitric Acid is the most important of the five compounds which oxygen forms with Nitrogen (q.v.). Until 1849 it was known only in the hydrated form (the *aqua fortis* of the older chemists), but in that year Deville showed that *Anhydrous Nitric Acid*, or *Nitric Anhydride*, N_2O_5 (see NITROGEN), might be obtained in transparent colourless crystals by the action of perfectly dry chlorine gas on well-dried crystals of nitrate of silver, the reaction being exhibited in the equation:

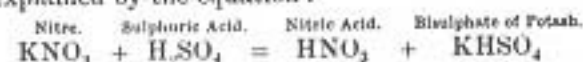


It is a very unstable compound, and sometimes explodes spontaneously. It dissolves in water with evolution of much heat, and forms hydrated nitric

acid. Nitric Acid (sym. HNO_3 ; equiv. 63; sp. gr. 1.530), when perfectly pure, is a colourless, limpid, fuming, powerfully caustic fluid, possessing an intensely acid reaction, as shown by its action on litmus. It boils at 187° (86° C.). It parts very readily with a portion of its oxygen to most metals, and hence is used in the laboratory as an oxidising agent. Whether in the concentrated or in a more dilute form, it acts energetically on organic matters. As examples of such actions we may refer to its power of decolorising indigo; of staining the skin and all albuminous tissues of a bright-yellow colour; of coagulating fluid albumen; and of converting cotton fibre into an explosive substance (see GUN-COTTON). The applications of this acid in the arts, in manufactures, and in chemical processes are very extensive.

The concentrated acid, HNO_3 , is by no means a stable compound. If it be exposed to the action of light it is decomposed with the formation of lower oxides of nitrogen; and mere distillation produces a similar effect. When it is mixed with water it emits a sensible amount of heat, owing to the formation of a much more stable hydrate, $2HNO_3 + 3H_2O$, which distils at 250° (121° C.) without change, and is unaffected by exposure to light. Its specific gravity is 1.424; and it is found that a weaker acid when heated parts with its water, and a stronger acid with its acid, till each arrives at this density. The existence of this hydrate has, however, been called in question by Roscoe. The so-called *Fuming Nitric Acid* is merely a mixture of the pure acid with one of the lower oxides.

Nitric acid does not occur naturally in a free state; but it is found tolerably abundantly in combination with potash, soda, lime, and magnesia; and after thunderstorms traces of it, in combination with ammonia, are found in rain-water. It may be formed in small quantity by passing a series of electric sparks through a mixture of its component gases in the presence of water, which is a mere imitation, on a small scale, of the mode in which it is produced in the atmosphere by a storm. It is usually prepared in the laboratory by the application of heat to a mixture of equal weights of powdered nitre (nitrate of potash) and oil of vitriol (hydrated sulphuric acid) placed in a retort. A combination of sulphuric acid and potash remains in the retort, while the nitric acid distils over, and is condensed in the receiver, which is kept cool by the application of a wet cloth. The reaction is explained by the equation:



During distillation red fumes appear, arising from the decomposition of a portion of the nitric acid and a formation of some of the lower oxides of nitrogen. In this operation *two* equivalents of oil of vitriol are taken for *one* of nitre, these being the proportions found by experience to be most suitable. If they are taken equivalent for equivalent, a very impure red fuming acid is the result. In the manufacture of nitric acid on the large scale the glass retort is replaced by a cast-iron cylinder coated with fire-clay, and the receiver by a series of earthen condensing vessels connected by tubes; and nitrate of soda (see NITRE) is substituted for nitre, in consequence of its being a cheaper salt, and of its containing 9 per cent. more nitric acid.

Nitric acid combines with bases to form *nitrates*, some of which, as those of potash, soda, oxide of ammonium, silver, &c., are anhydrous, while others combine with a certain number (often six) of equivalents of water of crystallisation. Most of them are soluble in water, crystallisable, and readily fusible by heat; and at an elevated temperature they are all decomposed, usually leaving only the oxide of the metal. If paper be soaked in a solution of a nitrate, allowed to dry, and ignited, it burns in the smouldering mode characteristic of *touch-paper*. This property is, however, shared by other salts.

The tests for this acid when it is present in small quantities are less satisfactory than those for the other ordinary mineral acids. All its compounds are so soluble that no *precipitant* for this acid is known. The best method for its detection is mixing the fluid to be tested with a solution of sulphate of iron, and then carefully pouring sulphuric acid through a tube to the bottom of the glass so as to form a lower layer. If much nitric acid is present a black colour is produced; if only a small quantity is present the liquid becomes reddish brown or purple; the dark colour being due to the formation of nitric oxide by the de-oxidising action of a portion of the iron salt on the nitric acid.

Medicinal Uses.—In the British pharmacopœia there is both a strong and a dilute acid. The strong acid has a specific gravity of 1.42, contains 70 per cent. of real acid, HNO_3 , while the diluted acid is prepared by mixing six ounces of the former with about twenty-five of distilled water, and has a specific gravity of 1.101. The dilute acid is used internally as a tonic in conjunction with bitter infusions. In many cases of biliousness, of chronic inflammation of the liver, and in syphilitic cases in which mercurials are inadmissible, it may be prescribed with great benefit, either alone or in conjunction with hydrochloric acid, externally as a bath or lotion, or internally in doses of about 20 minims properly diluted. The strong acid is useful as an escharotic; e.g. to destroy warts, some kinds of polypi, the unhealthy tissue in sloughing ulcers, &c., and as an application to parts bitten by rabid or venomous animals. Largely diluted—as 50 or 60 drops of the strong acid to a pint or more of water—it forms a stimulative application for torpid ulcers.

Nitrification is the changing of nitrogenous organic matter or ammonia compounds into nitrates. Possibly the nitrogen of the air under certain circumstances also undergoes this change in soils. Some authorities ascribe the change to 'a ferment,' 'an organised structure,' the 'micrococcus nitrificans,' &c., but it is a power possessed possibly by many micro-organisms. These nitrifying bacteroids perform their work under certain conditions. First, the temperature must be suitable, for at about 5° C. the process is stopped; but with a rise of temperature there is a proportionate increase of work—commencing at about 12° C.—until 37° is reached, which is the 'optimum' temperature, and from this onwards there is a diminution of action until the 'maximum' temperature of 55° C. is reached, when nitrification ceases. These bacteroids are annihilated at a temperature of 90° C., although the same result will follow drying even at a much lower temperature. The second condition is the presence of oxygen; and the third is the presence of a salifiable base, such as lime, potash, soda, &c., without which nitrification cannot proceed. Under these conditions nitrification goes on in every fertile soil, the atmospheric nitrogen, nitrogenous organic matter, or ammonia compounds being converted, in the presence of lime or potash, into the corresponding nitrates of lime or potash; and from these nitric compounds plants derive the most or all of their nitrogen, although some experimentalists maintain that some plants obtain part at least of their nitrogen from ammonia. See Lawes and Gilbert, *Proc. Roy. Soc.*, vol. xlvii.; Marshall Ward, *Phil. Trans.*, B. 1887, vol. clxxviii.

Nitro-benzol, $\text{C}_6\text{H}_5\text{NO}_2$, is a yellow, oily fluid, of sp. gr. 1.2, which may be distilled without decomposition, and boils at 415° (213° C.). It has a sweet taste, is insoluble in water, but dissolves freely in alcohol and ether. Its odour is very similar to that of oil of bitter almonds, which has led to its use in perfumery under the name of *Essence of Mirbane*. It is obtained by treating benzol, C_6H_6 , with warm fuming nitric acid, when one atom of hydrogen is replaced by the group of atoms NO_2 , so that the benzol, C_6H_6 , becomes converted into nitro-benzol, $\text{C}_6\text{H}_5\text{NO}_2$. The vapour of nitro-benzol when inhaled produces, after from 6 to 12 hours, coma and sometimes death. The fact that its action is so long delayed seems to indicate that its poisonous action is due to some product of its decomposition rather than to itself. In cases of poisoning artificial respiration and powerful stimulants should be resorted to.

Nitrogen (Fr. *azote*; sym. N; atom. wt. 14) is an elementary gas, which in the free state forms nearly four-fifths by volume of our atmosphere. In combination with other elements nitrogen is a necessary constituent of every organised body, and it forms a very large number of most important compounds. Its name (derived from *nitron*, 'nitre,' 'saltpetre,' and *gennaō*, 'I produce') was given to it shortly after it had been proved to be an essential constituent of nitre or potassium nitrate. Its presence in the atmosphere was discovered in 1772 by Rutherford, at that time a professor of botany in the university of Edinburgh. It was more particularly investigated soon after by Priestley, Scheele, and Lavoisier. It is a colourless, tasteless, inodorous gas, and was formerly regarded as permanent or incondensable; but it can be reduced to the liquid state by the application of sufficient pressure after it has been cooled to a very low temperature.

The Critical Temperature (q.v.) of nitrogen, or the point of temperature above which it cannot be condensed into a liquid by the application of any pressure however great, is -146° C. When cooled to this temperature a pressure of thirty-five atmospheres must be applied in order to liquefy it.

Nitrogen is fourteen times as heavy as hydrogen, and is slightly lighter, bulk for bulk, than atmospheric air, its sp. gr. being 0.9713, compared with air = 1. It is but slightly soluble in water, one hundred volumes of water at ordinary temperatures dissolving only about one and a half volumes of it.

Whilst nitrogen is a constituent of all plant and animal organisms and of many important compounds, it is, in the free state, rather inert towards other elements, and does not readily enter into direct combination with them. It is not combustible, nor does it act in the atmosphere as a supporter of combustion, a lighted taper plunged into a jar containing nitrogen being at once extinguished. It is almost unnecessary to say that nitrogen is not poisonous, since it is breathed freely along with oxygen by all animals; but it cannot support animal life, and an animal placed in it will die from suffocation for want of the oxygen necessary for respiration. Its function in the atmosphere seems to be mainly that of diluting the oxygen with which it is there associated. Although nitrogen forms about 79.1 per cent. of the total volume and 77 per cent.

of the total weight of the atmosphere, the free gas does not appear to play any important part in supplying nitrogen for the construction of the tissues of plants. Vegetable physiologists are at present actively inquiring into this question; and it appears to be definitely established that plants cannot directly absorb from the atmosphere the nitrogen which they require. It is found, however, that certain classes of plants when they are grown in a soil which is practically free from nitrogen compounds to start with do take up nitrogen. One explanation of this fact is that free atmospheric nitrogen becomes converted in small quantity into nitrogen compounds in the soil through the influence of micro-organisms present there. Another explanation attributes the fixation of nitrogen to micro-organisms existing in, or on the surface of, the plant. On the other hand, it has been conclusively shown that certain plants are unable to exist unless appropriate compounds of nitrogen are supplied to them in the soil in which they grow. The main supply of the nitrogen of plants is certainly drawn from nitrogen compounds existing in or artificially supplied to the soil. The most important of such nitrogen compounds are nitrates, which are present in every fertile soil. These may be produced by the decay in the soil of nitrogenous animal or vegetable matters existing in it or supplied to it as manure; or they may be added to it ready formed—as, for instance, in the form of sodium nitrate, which is frequently applied as a manure to soils poor in nitrates.

Many attempts have been made to discover methods by which the free nitrogen of the atmosphere could be converted on a manufacturing scale into nitrogen compounds, but as yet no workable and economical method has been discovered. There are numerous methods for preparing pure or nearly pure nitrogen. One method by which it is obtained very nearly pure is to remove the oxygen as completely as possible from atmospheric air. This can best be done by passing a current of air slowly through a red-hot tube packed with copper turnings or with spirals of copper wire gauze. The oxygen of the air combines with the copper to form an oxide of copper, whilst the nitrogen passes on. Or the oxygen can be very completely removed from a confined portion of moist air by suspending in it pieces of phosphorus until the volume of the gas ceases to diminish. Nitrogen can also be prepared by passing a current of chlorine gas into a solution of ammonia. In this method care must be taken always to use ammonia in excess, otherwise chloride of nitrogen would be produced, which is a dangerously explosive substance. A steady current of nitrogen can be very easily obtained by heating together strong solutions of ammonium chloride and of potassium nitrite. Owing to the great difficulty of forming compounds from free nitrogen, new compounds of nitrogen are generally prepared from compounds already existing. The most important of these compounds are the nitrates which are found in the soil in very considerable quantity in different parts of the world, and in some places occur in large deposits, as in the nitrate regions of South America. From these

nitrates Nitric Acid (q.v.) and other compounds of nitrogen are derived. Several compounds of nitrogen with oxygen are known.

Nitrous Oxide, or laughing-gas, N_2O , was discovered in 1772 by Priestley, who obtained it by the action on nitric oxide of easily oxidisable substances. It is now prepared by the action of heat on ammonium nitrate:



It is a colourless gas, which can with moderate ease be reduced to the liquid state, a pressure of thirty atmospheres being required to liquefy it at 0° C. Davy discovered in 1800 that it possessed anæsthetic properties, and it is now used as an anæsthetic in minor surgical operations. For such purposes it is stored in the liquid state by dentists and others in wrought-iron bottles. It is a supporter of combustion, and burning materials placed in it continue to burn with almost as great brilliancy as if placed in free oxygen.

Nitric Oxide, NO, is produced by the action of nitric acid on copper, silver, or mercury. It is a colourless gas, which like nitrogen can only be reduced to the liquid state by pressure after it has been cooled to a very low temperature. Its most striking character is the great readiness with which it unites with free oxygen, forming dense brown fumes, which consist mainly of peroxide of nitrogen.

Nitrous Anhydride has been described as a gas easily condensable to a liquid, possessing the composition represented by the formula N_2O_2 . It seems very questionable whether a single substance exists either in the state of gas or of liquid possessing this composition. The gas which was supposed to be nitrous anhydride was certainly a mixture. Although nitrous anhydride cannot be obtained pure, and the corresponding acid—nitrous acid—is an unstable substance at ordinary temperatures, a number of nitrites, salts corresponding to nitrous acid, are known.

Peroxide of Nitrogen, NO_2 or N_2O_4 , is produced when oxygen and nitric oxide are mixed. It is a dark-brown liquid at ordinary temperatures, which boils at 22°, yielding a brown vapour, and solidifies at -9°, forming colourless crystals.

Nitric Anhydride, N_2O_5 , is the anhydride of nitric acid, and can be obtained amongst other ways from nitric acid by the action on it of phosphoric anhydride (see NITRIC ACID).

The following are some of the other more important nitrogen compounds: ammonia and the ammonium salts (see AMMONIA); the vegetable alkaloids (see ALKALOIDS); aniline and its derivatives; cyanogen and the cyanides, including hydrocyanic acid; albumenoid substances; urea and uric acid; nitro-benzene, and other nitro compounds; pyridine and allied substances, hydrazine compounds, ptomaines, &c. See AZOTISED BODIES.

Nitro-glycerine (known also as *Glonoïn* or *Glonoïn-oil*) can be readily prepared by dissolving glycerine in equal measures of strong nitric and sulphuric acids and pouring the solution into water, when the nitro-glycerine becomes precipitated. Nitro-glycerine was discovered by Sobrero, a young Italian chemist at Paris, who in 1846 found that by the above process he could produce a highly explosive mixture. There was little idea at the time of the value of the discovery, which was treated solely as a chemical curiosity, until about fifteen years later, when Alfred Nobel, a Swedish engineer and chemist, perceiving the value of the unrecognised explosive and turning his attention to its development, rapidly introduced it as a blasting agent for industrial purposes. The new explosive was eminently satisfactory so far as blasting power was concerned; but a series of fearful accidents, notably that to the ship *European* at Panama in 1866—numerous expedients devised to render it safe in transit notwithstanding—called public attention to the danger inseparable from its conveyance, and in 1869 parliament, so far as Britain was concerned, placed its veto on nitro-glycerine.

The drawbacks which culminated in this prohibition led to the production of the nitro-glycerine compounds, now forming a large group, notably dynamite (see DYNAMITE, Vol. IV. p. 144), in which nitro-glycerine, absorbed by some inert porous substance, is thereby rendered safe from the dangers incident to the employment of nitro-glycerine without such treatment. Nitro-glycerine, as manufactured on a large scale for commercial

purposes, is formed by the mixture of strong nitric and sulphuric acids, cooled by water, previous to being introduced into a large leaden vessel, the temperature of which is kept down by water circulating through coils inside. Glycerine is then injected by compressed air as a fine spray, and becomes immediately nitrated, considerable heat being evolved. On the completion of the nitration, as indicated by the fall of temperature, the mixture is run off into another leaden vessel and allowed to stand. In about an hour the separation is complete. The nitro-glycerine, after being thoroughly washed in water and subsequently in an alkaline solution to remove every trace of acid, is ready for manufacture into dynamite or other nitro-glycerine compounds.

The utmost care is exercised in the above processes, and any abnormal rise in temperature is strictly guarded against, or accidents would arise. For similar reasons the materials employed in the manufacture of nitro-glycerine are in every particular the best and purest attainable. Colourless when pure, but having as an article of commerce a pale brown colour, nitro-glycerine is a dense, oily liquid, having a specific gravity of 1.6. It is inodorous, but has a sweet, pungent, aromatic taste; a single drop, however, if placed on the back of the tongue, will produce headache and pain in the back lasting for hours. By those accustomed to handling this substance, no inconvenience whatever is experienced. Nitro-glycerine enters into medical prescriptions for certain diseases of the heart.

If ignited in the open air nitro-glycerine burns rapidly and with a brisk flame without any explosion; and if poured out in a thin sheet it ignites with difficulty and burns incompletely; but it explodes at once if it is exposed to a moderately strong blow or concussion, to the concussion due to the explosion of gunpowder, to contact with red-hot iron, and especially to the action of detonating mixtures and fulminates. It likewise explodes on exposure to a high temperature, the exploding-point for nitro-glycerine compounds being about 420° F.; but 150° to 180° F. is sufficient to set up decomposition in the cartridge, and this will quickly raise the temperature to exploding-point. According to Dr Rudolf Wagner, nitro-glycerine, if chemically pure, may be cooled down to 4° without becoming solid; that of commerce, however, becomes solid if exposed for a considerable time to a temperature of about 40° to 45° F., crystallizing in long needles, which are most dangerous to handle, since they explode, even if gently broken, with much violence. In such condition the nitro-glycerine compounds should not be used for blasting, but can be readily thawed in a simple form of pan heated by hot water. At 320° nitro-glycerine begins (according to Adriani) to decompose, giving off red vapours; and if the heat be suddenly applied, or slightly raised above this point, violent explosion will occur. For equal bulks nitro-glycerine is calculated to be thirteen times as strong as gunpowder, while for equal weights it is eight times as powerful.

Nitro-glycerine compounds have been employed in the largest blasts that have been made, notably those at Hell Gate (see **BLASTING**). The manufacture of nitro-glycerine compounds in Great Britain is strictly controlled by legislation, and carried on under government supervision. See Eissel, *Handbook of Modern Explosives* (1891).

Nitrous Ether, or **NITRITE OF ETHYL**, $C_2H_5NO_2$, is a very volatile ether, with an agreeable apple odour, and having a specific gravity of .900. It boils at 64.4° (18° C.), and is highly inflammable. It is readily soluble in alcohol and glycerine, less so in water. It is very liable to decomposition, becoming acid on keeping. It may be prepared by the action of sulphuric acid and alcohol on nitrite of potash. In itself it is of little importance, but on account of its relation to the sweet spirits of nitre or spirit of nitrous ether is one of the most important drugs. It was for long thought that the virtues of this valuable remedy were proportionally due to the nitrous ether present, and attention was directed to the preparation of the pure substance. When this was administered in the form of solution of the strength of sweet spirits of nitre, it was found that its action was different from and inferior to that of the latter. The sweet spirits of nitre contains in addition aldehyde and paraldehyde, and it is believed that to these we must ascribe much of its virtue. Be this as it may, the legal test is based on the

presence of some ethereal body, presumably nitrite of ethyl, and yet many a sample may be efficacious and fail to satisfy the standard test. The spirit should be freshly made, be kept in well-closed bottles, and should not be acid. Its specific gravity should not exceed .845, as an admixture of water tends towards decomposition. It may be prepared by the action of nitric and sulphuric acids on alcohol in the presence of copper, but manufacturers attain the same end by other processes. It is used, in conjunction with other medicines, as a diuretic, especially in the dropsy which follows scarlatina; and it is employed, in combination with acetate of ammonia and tartarised antimony, in febrile affections. The dose in febrile cases is from half a drachm to a couple of drachms; while for a diuretic two or three drachms should be given.

Nose, the organ of smell, and also part of the apparatus of respiration and voice. Considered anatomically, it may be divided into an external part—the projecting portion, to which the term *nose* is popularly restricted—and an internal part, consisting of two chief cavities, or *nasal fossæ*, separated from each other by a vertical septum, and subdivided by spongy or turbinated bones projecting from the outer wall into three passages or *meatuses*, with which various cells or *sinuses* in the ethmoid, sphenoid, frontal, and superior maxillary bones communicate by narrow apertures.

The external portion of this organ may be described as a triangular pyramid which projects from the centre of the face, immediately above the upper lip. Its summit or root is connected with the forehead by means of a narrow bridge, formed on either side by the nasal bone and the nasal process of the superior maxillary bone. Its lower part presents two horizontal elliptical openings, the *nostrils*, which overhang the mouth, and are separated from one another by a vertical septum. The margins of the nostrils are usually provided with a number of stiff hairs (*vibrissæ*), which project across the openings, and serve to arrest the passage of foreign substances, such as dust, small insects, &c., which



Fig. 1.—Longitudinal Section of the Nasal Fossæ of the Left Side, the Central Septum being removed:

1, frontal bone; 2, nasal bone; 3, part of ethmoid bone; 4, sphenoidal sinus. a, superior turbinate bone; b, superior meatus; c, middle turbinate bone; dd, middle meatus; e, inferior turbinate bone; f, inferior meatus; gg, a probe passed into the nasal duct.

might otherwise be drawn up with the current of air intended for respiration. The skeleton or framework of the nose is partly composed of the bones forming the top and sides of the bridge and partly of cartilages, there being on either side an upper lateral and a lower lateral cartilage, to the latter of which are attached three or four small cartilaginous plates, termed *sesamoid cartilages*; there is also the cartilage of the septum which separates the nostrils, and in association posteriorly with the perpendicular plate of the ethmoid, and with the vomer, forms a complete partition between the right and left nasal fossæ. It is the lower lateral, termed by some writers the *alar cartilage*, which by its flexibility and curved shape forms the dilatable chamber just within the nostril. The nasal cartilages are capable of being slightly moved, and the nostrils of being dilated or contracted by various small muscles.

The *nasal fossæ*, which constitute the internal part of the nose, are lofty and of considerable depth. They open in front by the nostrils, and behind they terminate by a vertical slit on either side in the upper part of the pharynx, above the soft palate; and near the orifices of the Eustachian

tubes, leading to the tympanic cavity of the ear.

The mucous membrane lining the nose and its cavities is called *pituitary* (Lat. *pituita*, 'rheum'), from the nature of its secretion; or *Schneiderian*, from Schneider, the first anatomist who showed that the secretion proceeded from the mucous membrane, and not, as was previously imagined, from the brain; it is continuous with the skin of the face at the nostrils, with the mucous covering of the eye through the lachrymal duct (see **EYE**), and with that of the pharynx and middle ear posteriorly. This membrane varies in its structure in different parts of the organ. On the septum and spongy bones bounding the direct passage from the nostrils to the throat the lining membrane contains ample and capacious submucous plexuses of both arteries and veins, of which the latter are by far the more large and tortuous. These plexuses, lying as they do in a region exposed more than any other to external cooling influences, appear to be designed to promote the warmth of the part, and to elevate the temperature of the air on its passage to the lungs. They also serve to explain the tendency to hemorrhage from the nose in cases of general or local plethora. In this, the respiratory part of the nose, the mucous membrane

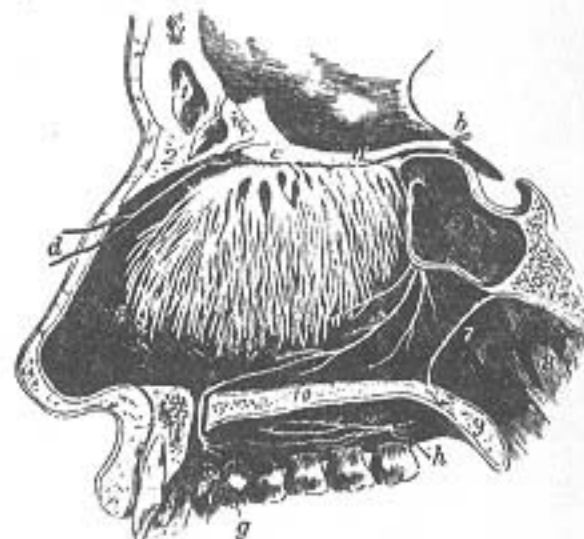


Fig. 2.—Distribution of the Olfactory Nerve on the Septum of the Nose:

1, frontal sinus; 2, nasal bone; 4, sphenoidal sinus of left air; 7, posterior opening of the left nostril; 8, opening of Eustachian tube; 9, section of soft palate; 10, section of hard palate. a, olfactory nerve; b, its three roots; c, its bulb; d, nasal branch from the ophthalmic division of the fifth nerve; e, nasopalatine nerve; g, h, its branches; i, septum of the nose.

is lined by ciliated epithelium. In the upper third of the nose—which, as the proper seat of the sense of smell, may be termed the *olfactory region*—the mucous membrane is very thick and coloured by a brown pigment. The olfactory nerve, or nerve of smell, terminates in the olfactory mucous membrane. It passes into the nasal cavity in several small branches; these ramify in the soft mucous membrane (fig. 2), and end in tiny varicose fibres which terminate in elongated epithelial cells projecting into the free surface of the nose. These cells—the *olfactory cells*—which in some animals are provided with little hairs, are affected by odorous particles, and the excitement thus set up travels to the brain by the branches of the olfactory nerve. In order to smell a substance it must be in the form of vapour. A scent such as Eau de Cologne when poured into the nostril is odourless; its little particles must be disengaged, and be carried freely by the atmosphere into the nasal cavity before we are affected by its odour. So sensitive is the nose, however, that odorous particles of inconceivable smallness are capable of producing powerful sensations. When we remember that a grain of musk will scent the air in its neighbourhood for years, and that this can only be by the continual loss of particles of its substance, these particles must be infinitely minute. Still more wonderful is the development of the sense of smell in many of the lower animals. A hare passes rapidly over the ground and the scent will under favourable circumstances remain for hours, and be sufficiently strong to enable the well-trained harrier to follow it with unerring accuracy. In savage tribes the sense of smell is vastly more acute than among civilised nations; nevertheless by practice it is possible for any one to cultivate this sense to a very considerable extent. Well-authenticated cases are recorded of persons obliged by the loss of

the other senses to train this, the only one left for their use, to such a degree of acuteness that they have been able to recognise both objects and persons by the sense of smell alone.

Most persons imagine that we are largely beholden to 'taste' for our gustatory pleasures. In reality our sense of taste only enables us to distinguish sweet from sour or bitter, and all the flavour of the food or wine is smelt. Close the nose and shut the eyes, and one cannot distinguish port from sherry, a raw potato from an apple, or beef from mutton.

Until recent years it was impossible to connect the quality of a smell with the kind of substance that produced it. In hearing and sight the character of the vibrations—of air or ether—determines the kind of sensation. The sound peculiar to the violin or piano depends entirely on the character of the sound vibrations given out by them. The rose appears red because it reflects to the eye vibrations which are chiefly characterised by their big oscillations. The writer of this article has been able to establish a similar relationship between the character of a smell and the character of the vibrations associated with odorous particles. He finds, in studying the odours of elements and their compounds, that in the 'Groups' of Mendeleëff (see *ATOMIC THEORY*, Vol. I. p. 552) the odours are similar or vary with the atomic weight of the element. Exactly similar properties in respect to the production of colour sensations have been observed by Carnelly.

DISEASES OF THE NOSTRILS.—Acute inflammation of the nasal mucous membrane has been already described under the title of Catarrh (q.v.); the conditions which cause an offensive smell from the nostrils are discussed in the article OZENA; and Polypus is a separate article.

Hemorrhage from the Nostrils, or Epistaxis (Gr., 'a dropping'), is by far the commonest form of bleeding from a mucous membrane. It may be produced by direct injury, as by a blow on the nose, or a scratch in the interior of the nostrils; and by other local conditions, as ulcerations or morbid growths in the nasal cavity. According to Sir Morell Mackenzie, 'constitutional causes are of four kinds: (1) the blood itself may be diseased; (2) the vessels may be diseased; (3) there may be obstruction to the circulation through the lungs, liver, kidneys, or other organs, causing a sudden tension or strain of the whole system, which gives way at a weak part—viz. the nose . . . ; (4) the blood-flow may be a vicarious discharge' (*Diseases of the Throat and Nose*). It is most common in children and young adults, least so in the prime of life. It is much more often met with in the male sex than the female. The bleeding usually occurs drop by drop, but may be very profuse. Sir Thomas Watson wisely says: 'Sometimes it is a remedy; sometimes a warning; sometimes itself a disease.' The first question to be considered therefore in any particular case is whether the hemorrhage ought to be arrested. Generally speaking, in plethoric children and young people, in cases of venous obstruction, and in vicarious hemorrhage, it should not be stopped unless the loss of blood prove excessive.

When it is desirable to arrest the hemorrhage the patient should be placed in the sitting posture at an open window, with the head erect or slightly inclined backwards; and amongst the simpler means to be first tried are compression of the nostrils by the fingers, maintained for five or ten minutes, the application of a key or other piece of cold metal to the back of the neck, and the bathing of the face or whole head with cold water, especially if accompanied by a drawing-up of the water into the nostrils; should these means fail, recourse must be had to astringent injections (for example, twenty grains of alum dissolved in an ounce of water) thrown up the nostrils by a syringe, or to astringent powders (as finely-powdered galls, kino, matico, alum, &c.) blown up the nostrils by means of a quill or other tube, or snuffed up by the patient. As a final resource the nostrils must be plugged with strips of lint, absorbent wick, or a piece of sponge. Cases occasionally occur in which it is necessary also to plug the posterior orifices of the nostrils by an operation, into the details of which it is not necessary to enter.

Post-nasal Catarrh is a chronic and very troublesome disease, most common in America, especially the United States; so much so that it is there usually called simply catarrh, and elsewhere is sometimes spoken of as American catarrh. The

symptoms are discomfort at the back of the nose, leading to frequent 'hawking' to clear away the tenacious mucus which is formed there, and sometimes indistinctness in articulation. The causes are not well understood: Sir Morell Mackenzie believes that the chief is the inhalation of irritating dust. Treatment must be chiefly directed to the local condition; alkaline sprays or washes should be used to remove the adherent secretion, and then an astringent powder or a thin ointment snuffed up the nostrils: catechu, red (Eucalyptus) gum, or sulphate of iron, diluted with starch, and soft vaseline, either alone or with one-eighth of finely-powdered boracic acid, are among the most useful applications. Health otherwise defective may indicate the importance of constitutional treatment; and change of climate is sometimes useful.

When the nose or a portion of it has been destroyed by disease or accident, the defect may be partly made good by the Rhinoplastic (q.v.) operation.

Ochres are native pigments consisting of clays or earths composed chiefly of silica and alumina, along with oxide of iron or more rarely with other oxides. Some are found in a natural state fine enough to be used after being simply washed. The two important classes of ochres are the yellow and the red, the colouring material of the former being the hydrated oxide of iron, and that of the latter the red or sesquioxide. Umber (q.v.), which is classed with the ochres, contains manganese as well as oxide of iron. Yellow ochres are reddened by being burned. Most of the ochres can be prepared artificially, but these are not so safe for artists' purposes as the native earths. The latter are remarkable for their stability, as can be seen in many pictures by the old masters. Yellow ochre and Roman ochre are much used both by artists and house-painters, and so also (but the first more by artists) are the red ochres, known as light red, Indian red, and Venetian red. This last, however, is an artificial product, and, although it is an oxide of iron colour, it contains no earthy base, so that correctly speaking it is not an ochre.

Oils (including Fats). The fats and fixed oils constitute an important and well-marked group of organic compounds, which exist abundantly both in the animal and vegetable kingdoms. They are not simple organic compounds, but each of them is a mixture of several such compounds to which the term *glycerides* is applied; and the glycerides which by their mixture in various proportions form the numerous fats and oils are mainly those of palmitic, stearic, and oleic acids, and to a less extent those of other fatty acids, such as butyric, caproic, caprylic, and capric acids, which are obtained from butter, myristic acid, which is obtained from coconut oil, &c. The members of this group may be solid and hard, like suet; semi-solid and soft, like butter, horse-grease, and lard; or fluid, like the oils. The solid and semi-solid are, however, usually placed together and termed fats, in contradistinction to the fluid oils. The most solid fats are readily fusible, and become reduced to a fluid or oily state at a temperature lower than that of the boiling-point of water. It is not until a temperature of between 500° and 600° F. is reached that they begin nearly simultaneously to boil and to undergo decomposition, giving off acrolein (an acrid product of the distillation of glycerine) and other compounds. In consequence of this property these oils are termed *fixed oils*, in contradistinction to a perfectly separate group of oily matters, on which the odoriferous properties of plants depend, and which, from their being able to bear distillation without change, are known as *volatile oils*. These, which are also known as *essential oils*, differ in toto in their chemical composition from the compounds we are now considering. All the fats and oils are lighter than water, and are perfectly insoluble in that fluid. Their specific gravity ranges from about 0.91 to 0.94. They dissolve in ether, oil of turpentine (one of the volatile oils), benzol, and to a certain extent in alcohol; while, on the other hand, they act as solvents for sulphur, phosphorus, &c. These bodies possess the property of penetrating paper and other fabrics, rendering them transparent, and producing what is well known as a greasy stain. They are not readily inflammable unless with the agency of a wick, when they burn with a bright flame. In a pure and fresh state they are devoid of taste and smell,

but on exposure to the air they become oxidised and acid, assume a deeper colour, evolve a disagreeable odour, and are acrid to the taste; or, in popular language, they become rancid. The rapidity with which this change occurs is considerably increased by the presence of mucilaginous or albuminous bodies. The rancidity may be removed by shaking the oil in hot water in which a little hydrated magnesia is suspended.

The general diffusion of fats and oils in the animal kingdom has been already described (see FATS). In the vegetable kingdom they are equally widely distributed, there being scarcely any tissue of any plant in which traces of them may not be detected; but they are specially abundant in the seeds. The seeds of the Cruciferae are remarkably rich in oil; linseed yielding fully 20 per cent., and rape-seed about 40 per cent. of oil; and some fruits, as those of the olive and oil-palm, yield an abundance of oil.

The uses of oils and fats are numerous and highly important, many being extensively employed as articles of food, as medicines, as lubricating agents, in the preparation of soaps, ointments, varnishes, pigments, for candles, lamps, and other means of illumination, and for the purpose of dressing leather, &c. In Africa, Asia, and the Pacific animal and vegetable oils and fats are much used for anointing the person and smearing the hair, thus affording a protection against heat

and the attacks of insects, and checking excessive perspiration. This practice conduces to health and preserves the skin smooth and soft. Oil thrown on the sea has a remarkable effect in subduing the force of the waves. A few gallons cast upon stormy seas moderates and prevents the waves breaking with force. This practice might be adopted by lifeboats when approaching wrecks, and rescuing the crews of stranded vessels. The composition of the fine oils required for watches and sewing-machines is often carefully kept secret. Those principally used are hen, almond, olive, and neat's-foot. The oils suitable for machine-shops and general cotton and woollen machinery require a good body, rather viscid. For woollen spindles a lighter oil, and for cotton spindles, which have a speed of 4000 revolutions per minute, an oil of still lighter body. For lubricating purposes mineral oils may with advantage be mixed with animal and vegetable oils to diminish their tendency to thicken; the more fluid an oil is the less friction takes place.

(1) **Vegetable Fats.**—The chief solid fats of vegetable origin are cocoa-nut oil, nutmeg-butter, cocoa-butter, and palm-oil. The fluid vegetable fats or oils are divisible into the *non-drying* and the *drying oils*; the latter being distinguished from the former by their becoming dry and solid when exposed in thin layers to the air, in consequence of oxygenation. Some of the drying oils, when mixed with cotton, wool, or tow, absorb oxygen so rapidly, and consequently become so heated, as to take fire, and many cases of the spontaneous combustion of heaps of oily materials that have been employed in cleaning machinery have been recorded. The chief non-drying oils are olive-oil, almond-oil, and colza-oil; while the most important drying oils are those of linseed, hemp, poppy, and walnut; castor-oil seems to form a link between these two classes of oils, since it gradually becomes hard by long exposure to the air.

(2) **Animal Fats.**—The chief solid fats are beef and mutton suet or tallow, lard, butter, goose-grease, &c.; while among the fluids sperm-oil, ordinary whale-oil, cod-liver oil, and neat's-foot oil may be especially mentioned. In many of their characters spermaceti and beeswax resemble the solid fats. As a general rule, stearin and palmitin, both of which have comparatively high fusing-points (between 157° and 114° F.), preponderate in the solid fats; while olein, which is fluid at 32°, is the chief constituent of the oils.

When any of these bodies are heated with the hydrated alkalies they undergo a change which has long been known as Saponification, or conversion into Soap (q.v.), in which the fatty acid combines with the alkali to form a soap, while the sweet viscid liquid glycerine is simultaneously formed. When the fatty acids are required on a large scale, as for the manufacture of the so-called stearin candles, which in reality consist mainly of stearic and palmitic acids, sulphuric acid and the oil or fat are made to act upon each other at a high temperature (see CANDLE). The fatty acids may

also be procured in a very pure form by the injection of superheated steam at a temperature of between 500° and 600° into heated fat. A complete list of even the chief fats and fixed oils would take up far more space than we can command. The more important are noticed in separate articles, such as Fixed Oil of Almonds, Castor-oil, Croton-oil, &c., and some account given of their properties and uses; or under the names of the substances from which they are procured—Linseed, Rape, Candle-nut, Cocoa-nut, Cotton (for Cotton-seed Oil), &c. Reference may also be made to the articles on Butter, Ghee, Lard, Cod-liver Oil, &c.

The Volatile or Essential Oils exist, in most instances, ready formed in plants, and are believed to constitute their odorous principles. They form an extremely numerous class, of which most of the members are fluid. Many used for flavouring are artificially compounded (see BUTYRIC ACID). Essential oils are much employed in perfumes, for flavouring liqueurs and confectionery, and for various purposes in the arts. They will be described at PERFUMERY. The mineral oils will be found discussed under the heads of Naphtha, Paraffin, Petroleum.

Oleander (*Nerium*), a genus of plants of the natural order Apocynaceae. The species are evergreen shrubs with leathery leaves, which are opposite or in threes; the flowers in false umbels, terminal or axillary. The Common Oleander (*N. oleander*), a native of the south of Europe, the north of Africa, and many of the warmer temperate parts of Asia, is frequently planted in temperate countries as an ornamental shrub, and is not uncommon in Britain as a window-plant. It has beautiful red, or sometimes white flowers. The English call it Rose Bay, and the French Rose Laurel (*Laurier Rose*). It attains a height of eight or ten feet. Its flowers give a splendid appearance to many ruins in the south of Italy. It delights in moist situations, and is often found near streams. All parts of it contain a bitter and narcotic acid juice, poisonous to men and cattle, which flows out as a white milk when young twigs are broken off. Cases of poisoning have occurred by children eating its flowers, and even by the use of the wood for spits or skewers in roasting meat. Its exhalations are injurious to those who remain long under their influence, particularly to those who sleep under it. A decoction of the leaves or bark is much used in



Common Oleander (*Nerium oleander*).

the south of France as a wash to cure cutaneous maladies. *N. odoratum*, an Indian species, has larger flowers, which are very fragrant. *N. piscidium* (or *Eschaltum piscidium*), a perennial climber, a native of the Khasia Hills, has a very fibrous bark, the fibre of which is used in India as hemp. The steeping of the stems in ponds kills fish.

Olefiant Gas, or ETHYLENE, C_2H_4 , is the most abundant illuminating constituent in coal-gas. It may be obtained by the destructive distillation of coal, but more readily by the action of sulphuric acid on alcohol. It is a colourless gas with a faint odour, but little soluble in water or alcohol. It may be liquefied by cold and pressure. With air it forms a powerfully explosive mixture, which, on being burned, yields water and carbonic acid gas. When mixed with an equal volume of chlorine, and kept cool and in the dark, the two

gases unite, with the production of drops of an oily liquid called Dutch Liquid (q.v.).

Olefines. See HYDROCARBONS.

Oleic Acid is one of the acids present in olive, almond, and other oils, in which it is united to glycerine. At temperatures above 57° (14° C.) it exists as a colourless limpid fluid, of an oily consistence, devoid of smell and taste, and (if it has not been exposed to air) exerting no action on vegetable colours. At 40° (4.4° C.) it solidifies into a firm, white, crystalline mass, and in this state it undergoes no change in the air; but when fluid it readily absorbs oxygen, becomes yellow and rancid, and exhibits a strong acid reaction with litmus paper. It is very difficult to obtain the acid in a state of purity, in consequence of the readiness with which it oxidises. It is obtained in a crude form, as a secondary product, in the manufacture of stearin candles; but when the pure acid is required a lengthy process, starting with almond oil, must be adopted. Oleic acid forms normal (or neutral) and acid salts; but the first compounds of this class that require notice are the normal salts of the alkalies. These are all soluble, and by the evaporation of their aqueous solution form soaps. Oleate of potash forms a soft soap, which is the chief ingredient in Naples soap; while oleate of soda is a hard soap, which enters largely into the composition of Marseilles soap. Of recent years a large number of oleates have come into use in medicine, which depend for their activity on the remarkable ease with which they are absorbed by the skin. Such are the oleates of zinc, mercury, lead, tin, morphia, &c., which, in this form, produce more rapid results than when applied as ointments.

Olein is a compound of oleic acid with glycerine, and constitutes the bulk of olive-oil. Along with it are associated stearin and palmitin, similar compounds of stearic and palmitic acids with glycerine.

Opium, one of the most valuable of medicines, is the dried juice of the unripe capsules of a species of Poppy (q.v.), *Papaver somniferum*, of which several varieties are cultivated, the most usual in India, Persia, and China being apparently the variety *album*. The cultivation of the poppy for the sake of opium is carried on in many parts of India, although the chief district is a large tract on the Ganges, about 600 miles in length and 200 miles in breadth, which is divided into two agencies, that of Behar and that of Benares, the central factory of the former being at Patna, and that of the latter at Ghazipur. The poppy is also extensively cultivated for opium in the Asiatic provinces of Turkey, in Egypt, in Persia, and in China; and opium of fair quality is produced, although not to any considerable amount, in some parts of Europe, and even in Britain.

The poppy requires for its profitable cultivation a rich soil, and in India is generally sown in the neighbourhood of villages where manure can be easily obtained. The soil ought to be fine and loose when the seed is sown. The subsequent cultivation consists chiefly in thinning and weeding. Irrigation is practised. Mild moist weather, with night-dews, is deemed most favourable during the time of the collection of the opium. Very dry weather diminishes the flow of the juice, and much rain is injurious. The opium poppy is cultivated for its seed or oil and other purposes besides the production of opium, concerning which see POPPY.

Opium, as a commercial article, is of great importance, exceeding indeed that of any other drug in use. The cultivation of the opium poppy in British India forms a most extensive branch of agriculture, and the collection and preparation of the drug itself employs a large number of persons. The seed is sown in India in the beginning of November; it flowers in the end of

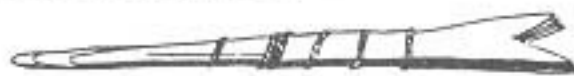


Fig. 1.

January, or a little later; and in three or four weeks after the capsules or poppy-heads are about the size of hens' eggs, and are ready for operating upon. When this is the case the collectors each take a little instrument (fig. 1), made of four small knives tied together, the blades appearing like the

teeth of a comb; with these instruments they wound each half-ripe poppy-head (fig. 2) as they make their way through the plants in the field. This is always done in the afternoon, and on the following morning the milky sap is collected by scraping it off with a kind of scoop, and transferred to an earthen vessel hanging at the side

of the collector. When this is full it is carried home and placed in a shallow open brass dish, and left for a time tilted on its side, so that any watery fluid may drain out; this watery fluid is very detrimental to the opium unless removed. It now requires daily attention, and has to be turned frequently, so that the air may dry it equally, until it acquires a tolerable consistency, which takes three or four weeks; it is then packed in small earthen jars, and taken to the factories, where the contents of each jar are turned out and carefully weighed, tested, valued, and credited to the cultivator. The opium is then thrown into vast vats, which hold the accumulations of entire districts, and the mass being kneaded is again taken out and made into balls or cakes for the market. After being fully dried these balls are packed in chests for the market.

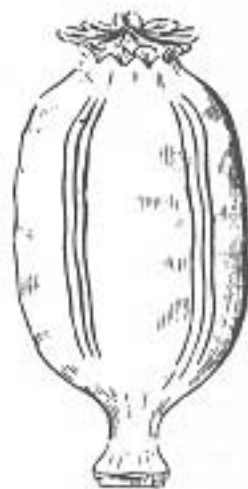


Fig. 2.

In Europe opium is mainly used for medicinal purposes, and large quantities of it undergo further manufacture, in order to separate from it the active principles morphine, narcotine, &c. In Great Britain the chief manufacture of these salts of opium is carried on in Edinburgh, where two firms manufacture these products upon an immense scale, supplying probably a fifth of the whole quantity manufactured.

Chemical Properties, &c.—All kinds of opium have a bitter, nauseous taste, and a peculiar narcotic, heavy odour. Chemically it is a gum-resin containing a very large number of alkaloids, meconic and other acids, and the ordinary constituents of a plant juice. Its exact composition varies greatly, but is somewhat as follows: **Alkaloids**—morphine (4-15 per cent.), narcotine (4-6 per cent.), thebaine, codeine, narceine, papaverine (of each from about 1-1 per cent.), cryptopine, rhoadine, laudanine, laudanoline, pseudomorphine, codamine, meconine, protopine, lanthopine, papaveramine, oxynarcotine, hydrocotarnine, gnoscopine, tritopine, and others, all in very small amount. They exist free or in combination with meconic, lactic, sulphuric, and phosphoric acids. There is about 8 per cent. of saccharine matter, about 35 per cent. of gum, resin, fat, albumen, &c., various inorganic bases, and a variable amount of water. It may be adulterated with sugar, gum, or molasses, and sometimes contains nails, lead, or stones in the centre of the mass.

The chief and most easily applied chemical test for opium depends on the presence of meconic acid, which is an organic acid peculiar to it. A watery or alcoholic solution turns blood-red in colour on the addition of a solution of perchloride of iron, and this colour is discharged by a solution of protochloride of tin. Its smell and taste are also very characteristic. Turkey opium is generally considered the best, and in the British Pharmacopoeia it alone is directed to be used for making the official pharmaceutical preparations (twenty in number). Before use it must be dried and powdered, and standardised to a strength of as nearly as possible 10 per cent. of morphine. For making the official alkaloids any kind of opium may be used. A method of assaying the amount of morphine in it is given with great detail in the British Pharmacopoeia.

Action and Medicinal Uses.—The action of opium depends on its alkaloids, and is chiefly determined by the morphine present in it. Ordinary medicinal doses (1/4 to 3 grains) depress the activity of the brain and cause deep sleep with contracted pupils, slow respiration, and insensibility to pain. On awakening there are usually disagreeable after-effects, such as loss of appetite, slight nausea, constipation, mental fatigue, and headache. When minute doses are taken there ensue symptoms of excitement and

stimulation, as shown by increased mental and bodily activity, restlessness and sleeplessness. The imagination is more active, and mental work can be accomplished with greater ease and celerity. It is disputed whether these effects are due to actual stimulation of the brain, or whether the higher centres are blunted, and thus allow the imaginative faculties to have fuller play. Most probably the latter is the case. Self-consciousness and self-criticism are lulled, the judgment is less controlled by the higher centres and by impressions from without, and left to itself part of the brain lapses into uncontrolled activity. It is for these reasons that opium is habitually used by some brain-workers. Individual susceptibility and race influence its effects very largely. The Teutonic races and phlegmatic people in general tend to sleep after it, while Easterns and persons of highly nervous temperament tend to become excited. Man, owing to the greater development of his brain, is somewhat differently affected from the lower animals. Frogs, after a primary stage of narcosis, pass into a condition of exquisite tetanic spasm from stimulation of the spinal cord, and the lower mammalia exhibit the same condition to a lesser degree. In adult man tetanic convulsions are rarely seen, and only occasionally after enormous doses; but in children convulsions are not infrequent, the explanation given being that in them the spinal cord is relatively largely developed in proportion to the brain. Opium diminishes all the secretions except the sweat, and thus causes constipation. It does not materially affect the heart or circulation in medicinal doses.

When opium is used habitually a tolerance for it becomes established, and enormous doses may be taken without any special effects. In medicine it is used chiefly to procure sleep and relieve pain. For these purposes it has no equal. It is also employed to arrest secretions, to allay irritation, and in diarrhoea. In diabetes, heart disease, hemoptysis, and many other conditions it is given with great advantage. Probably no remedy has such wide and universal applications.

It must be given with great caution to young children, but many other factors, such as pain, habit, idiosyncrasy, and various diseases influence its action and dosage.

Poisoning.—About half the deaths from poison which occur in the United Kingdom are due to opium or its preparations. When the effects of a large dose become fully developed the person lies in deep coma and in a state of complete insensibility. Respiration is slow, noisy, and stertorous, the pupil is contracted to a 'pin-point,' and insensible to light, the pulse is rapid and weak, or sometimes full and slow, the face and skin generally are pale and livid, and covered with cold perspiration. Constant stimulation may rouse the patient partially, but he always tends to relapse into stupor. Death is due to paralysis of the respiratory centres in the brain, but may be due to apoplexy or collapse. Such are the usual symptoms, but many cases present peculiar features, such as convulsions, vomiting, diarrhoea, delirium, dilated pupils, and other anomalous symptoms. The *post-mortem* appearances are not characteristic, but the cerebral blood-vessels are usually very full, and there may be effusion of serum into the ventricles. The smallest fatal dose recorded for an adult is four grains, but enormous quantities are often taken without serious symptoms. In infants very minute doses ($\frac{1}{4}$ to $\frac{1}{2}$ grain) may prove fatal. Death may occur in about two hours or even less; few cases are prolonged beyond twenty-four hours.

The treatment consists in making the patient vomit, and in washing out the stomach with large quantities of water. Owing to the state of insensibility emetics sometimes fail to act. Atropine is often given subcutaneously, while coffee or tea or caffeine may be also freely given. The patient may be further aroused by keeping him moving about supported by attendants, by cold cloths applied to the chest, and by electric stimulation. Any violence or measures which tend to exhaust the patient should be carefully avoided.

Opium-eating.—The habitual consumption of opium or any of its preparations by persons otherwise in good health is known as opium-eating, the opium habit, morphine habit, or morphinism. Opium, laudanum, chlorodyne, black drop, nepenthe, morphine, and other forms are all used. They are most commonly taken by the mouth, the subcutaneous injection of Morphine (q.v.) being almost entirely confined to the more cultured and edu-

cated classes. Its habitual use is usually begun to relieve pain or sleeplessness, and one month's constant use is said to be sufficient in many cases to confirm the habit. The amount consumed by different individuals varies greatly. Of morphine most habitués take about three grains daily, some five or six grains, while a few go much higher. De Quincey says that at one time of his life he consumed 8000 drops of laudanum daily, but his ration was very excessive. The immediate effects are a feeling of stimulation and well-being, but as soon as these have passed off there ensues a state of despondency, to banish which a fresh dose is taken. It is a craving brought on by indulgence, and is to be ranked with such habits as drinking, smoking, gambling, &c. Many persons indulge this craving during their whole life, and do their daily work well. Such persons do not, however, go to any great excess, although they may have the craving as markedly as others who suffer intensely from well-developed symptoms of chronic opium poisoning. The typical opium-eater is lean and pale, with dull, glazed eyes; he suffers from chronic dyspepsia, from nervous irritability, and disturbances of the circulation. Albuminuria, glycosuria, and various other disorders are sometimes present. Sudden deprivation causes severe nervous disturbances and not seldom alarming collapse. For successful treatment of the opium craving the patient had better be removed from his own home and friends to some institution where he can be under strict and constant medical supervision. There is a difference of opinion as to whether the opium should be abruptly or gradually withdrawn. Recovery is generally complete in a few weeks, but relapses into the habit are exceedingly apt to occur.

Organo-metallic Bodies. Under this term are included a large number of chemical compounds in which organic radicals, such as methyl, CH_3 , ethyl, C_2H_5 , &c., are united to metals. Amongst the earliest obtained of these substances were those derived from the metal zinc. Zinc-methyl, $\text{Zn}(\text{CH}_3)_2$, and zinc-ethyl, $\text{Zn}(\text{C}_2\text{H}_5)_2$, which may be taken as examples of the class, are colourless liquids, heavier than water, which boil at 46° and 118° C. respectively. They take fire spontaneously in contact with air, and burn with the production of a dense white smoke of oxide of zinc. In contact with the skin they give rise to severe wounds which are very difficult to heal. They are decomposed with great energy by water. Substances analogous to these zinc compounds have been prepared, containing cadmium, magnesium, antimony, arsenic, bismuth, tin, aluminium, mercury, lead, sodium, potassium, and some rare metals.

Oxalic Acid, $\text{H}_2\text{C}_2\text{O}_4 + 2\text{H}_2\text{O}$, occurs in colourless, transparent, oblique, rhombic prisms, which have an intensely sour taste, and are soluble in nine parts of cold water, and much more freely in boiling water. When heated to 212° (100° C.) the crystals lose their two equivalents (or 28.5 per cent.) of water, and the residue, consisting of the anhydrous acid, $\text{H}_2\text{C}_2\text{O}_4$, becomes opaque. When the crystallised acid is rapidly heated to about 300° (149° C.), or when it is warmed with strong sulphuric acid, it is decomposed into carbonic acid and carbonic oxide gases, and into water. Oxidising agents, such as binoxide of manganese, peroxide of lead, nitric acid, &c., convert oxalic into carbonic acid, and on this property is based a good method of determining the commercial value of the black oxide of manganese. One of the most powerful of the organic acids, it expels carbonic acid and many other acids from their salts. The acid itself, which, like its soluble salts, is poisonous, is very widely diffused throughout the vegetable kingdom, sometimes in the free state, but more frequently as a salt of lime, as in rhubarb and many lichens. In the animal kingdom it never occurs except in minute quantity, and in combination with lime. It is produced by the action of either caustic potash or nitric acid upon most organic compounds of natural occurrence. Its most common mode of preparation is by the oxidation of starch or sugar by nitric acid. The organic compound and the nitric acid are heated in a flask till all effervescence has ceased, after which the solution is evaporated, and the oxalic acid separates in crystals on cooling. The most important salts are the oxalate of ammonia, $(\text{NH}_4)_2\text{C}_2\text{O}_4 + \text{H}_2\text{O}$, used as a test for lime, and the binoxalate of potash or salt of sorrel, $\text{KHC}_2\text{O}_4 + \text{H}_2\text{O}$, also known as essential

salt of lemons, and which is popularly used for removing ink-stains or for cleaning brass.

The best test for this acid is the production of a white precipitate (of oxalate of lime), on the addition of any soluble salt of calcium. The precipitate is insoluble in water, in solution of potash, and in acetic acid, but dissolves in the mineral acids. A solution of nitrate of silver also gives a white precipitate of oxalate of silver, which explodes when heated.

In consequence of its employment in cotton-printing, bleaching straw, &c., oxalic acid is more accessible to the general public than many other poisons; and on this account instances of suicide from the swallowing of this acid are by no means uncommon. Cases of accidental poisoning, moreover, sometimes occur from its being sold by mistake for Epsom salts. Large doses destroy life very rapidly. With the view of converting the free acid in the stomach into an insoluble and inert salt, chalk, whiting, or lime-water, with full draughts of milk, should be administered with the least possible delay. Salt of sorrel is almost as poisonous as the pure acid.

Oxidation is the term applied in chemistry, with a somewhat wide significance, to the changes which occur when elementary or compound substances enter into new combinations with oxygen. The majority of those chemical actions to which the term Combustion (q.v.) is applied are examples of oxidation. The products of the processes of oxidation are frequently (but not invariably) oxides.

Oxides are compounds of oxygen with other elements, and are amongst the most important of the classes of chemical compounds. Basic oxides and acid oxides are described in the article CHEMISTRY (q.v.). In addition to these two large classes of oxides there are numerous oxides which do not possess either basic or acid properties, or if at all only to a very insignificant degree.

Oxychlorides, chemical compounds containing both chlorine and oxygen in combination with some other element, and intermediate in composition between the oxides on the one hand and the chlorides on the other. Thus, antimonious oxychloride, SbOCl , is intermediate between antimonious oxide, Sb_2O_3 , and antimonious chloride, SbCl_3 .

Oxygen (sym. O, atom. wt. 16) is a colourless, inodorous, tasteless gas, long regarded as a 'permanent' gas, but liquefied by Pictet of Geneva for the first time in 1877. Its chemical affinities for other elementary substances are very powerful; with most of them it is found in combination, or may be made to combine, in more than one proportion; with several in as many as four different proportions; and there is only one element (fluorine) with which it does not enter into any combination. Owing to the intensity with which many of these combinations take place, this gas has the power of supporting Combustion (q.v.) in an eminent degree. It is only slightly soluble in water; 100 cubic inches of that liquid dissolving 4.11 cubic inches of gas at 32° , and only 2.99 inches at 59° . It is slightly heavier than air, its specific gravity being 1.1056.

Oxygen gas is not only respirable, but is essential to the support of animal life; and hence it was termed *vital air* by some of the older chemists. A small animal placed in a bell-glass containing pure oxygen will not be suffocated as soon as if it were placed in the same glass filled with atmospheric air. For further details on this property of oxygen, the reader is referred to the article RESPIRATION.

Oxygen is the most abundant and the most widely distributed of all the elements. In its free state (*mixed* but not *combined* with nitrogen) it constitutes about a fifth of the bulk, and considerably more than a fifth of the weight, of the atmosphere. In combination with hydrogen, it forms eight-ninths of all the water on the globe; and in combination with silicon, calcium, aluminium, &c., it enters largely into all the solid constituents of the earth's crust; silica—in its various forms of sand, common quartz, flint, &c.—chalk, limestone, marble, and all the varieties of clay, containing about half their weight of oxygen. It is, moreover, found in the tissues and fluids of all forms of animal and vegetable life, none of which can support existence independently of this element.

There are various laboratory methods of obtaining oxygen on the small scale, the simplest of

which consists in the exposure of certain metallic oxides to a high temperature. It was originally obtained by its discoverer, Dr Priestley, from the red oxide of mercury, which, when heated to about 750°, resolves itself into metallic mercury and oxygen gas. It may be obtained similarly from red oxide and peroxide of lead, the resulting products being protoxide of lead and oxygen.

The ordinary laboratory method commonly employed to obtain an abundant supply of oxygen consists in heating chlorate of potash, KClO_3 , which yields up all its oxygen (amounting to 39.16 per cent.), and leaves a residue of chloride of potassium. One ounce of this salt yields nearly two gallons of oxygen gas. It is found by experiment that if the chlorate of potash is mixed with about a fourth of its weight of black oxide of copper, or of binoxide of manganese, the evolution of the gas is greatly facilitated, although the oxides do not seem to undergo any change during the process.

Various processes have been proposed for obtaining oxygen on the large scale, but only in recent years has the commercial production of the gas been carried out sufficiently cheaply to enable oxygen to be employed extensively for industrial purposes. The method employed by Brin's Oxygen Company consists in passing air under pressure over barium oxide, BaO , heated to a temperature of dull redness. In this way a quantity of barium peroxide, BaO_2 , is formed, and this can be made to again yield up its extra oxygen in the pure state (being reduced again to BaO) by heating to a full red heat, or, as is actually done in practice, by greatly diminishing the gaseous pressure without altering the temperature. It is estimated that oxygen can be produced by this process at a cost of from 5s. to 7s. 6d. per 1000 cubic feet. Oxygen can now be obtained in practically any required quantity in wrought-steel cylinders, in which it is compressed up to a pressure of 120 atmospheres.

Of the compounds of oxygen it is unnecessary to speak here, as they are described in the articles on the other chemical elements.

Oxygen was discovered almost simultaneously, in the year 1774, by Priestley and by Scheele, the English chemist having the precedence by a few weeks. Priestley gave it the name of *Dephlogisticated Air*; Scheele termed it *Empyreum Air*; Condorcet shortly afterwards suggested *Vital Air*, as its most appropriate designation; and in 1789 Lavoisier, who, by a series of carefully conducted and very ingenious experiments, proved that the combustion of bodies in the air consisted essentially in their chemical combination with oxygen, and thus overthrew the *Phlogiston* (q.v.) theory, gave it the name which it now retains (from *oxys*, 'acid,' and *gennao*, 'I produce'), in consequence of his (erroneously) believing that it was a necessary constituent of every acid.

Ozone (Gr. *ozō*, 'I smell'). It was remarked long ago that a peculiar odour was produced by the working of an electrical machine. Van Marum found that, when electric sparks were passed through a tube containing oxygen, the gas became powerfully impregnated with this odour—which he therefore called the 'smell of electricity.' Subsequent writers attributed the phenomenon to the formation of nitric acid, due to a trace of nitrogen mixed with the oxygen; especially as the gas was found to act energetically upon mercury. Thus supposed to be explained, these curious results were soon forgotten. But in 1840 Schönbein (q.v.) with remarkable acuteness made a closer investigation of the question, and arrived at many most curious results, all of which have not even yet been satisfactorily accounted for. The problem remains, in fact, one of the most perplexing, as well as interesting, questions imperfectly resolved in chemistry. The earlier results of Schönbein were these: (1) When water is decomposed by the voltaic current, the electrodes being of gold or platinum, the oxygen (which appears at the positive pole) possesses in a high degree the smell and the oxidising power developed by Van Marum by means of friction-electricity. (2) When the positive electrode is formed of an oxidisable metal these results are not observed, but the electrode is rapidly oxidised. (3) The oxygen collected at a platinum electrode retains these properties for an indefinite period if kept in a closed vessel; but loses them by heating, by the contact of an oxidisable substance, and even by contact with such bodies as charcoal and oxide of manganese. To the substance, whatever it may be, which possesses

such powerful chemical affinities, Schönbein gave the name ozone, from its smell. In 1845 he showed that the same substance can be produced by the action of phosphorus on moist air, and hinted that it might be a higher oxide of hydrogen.

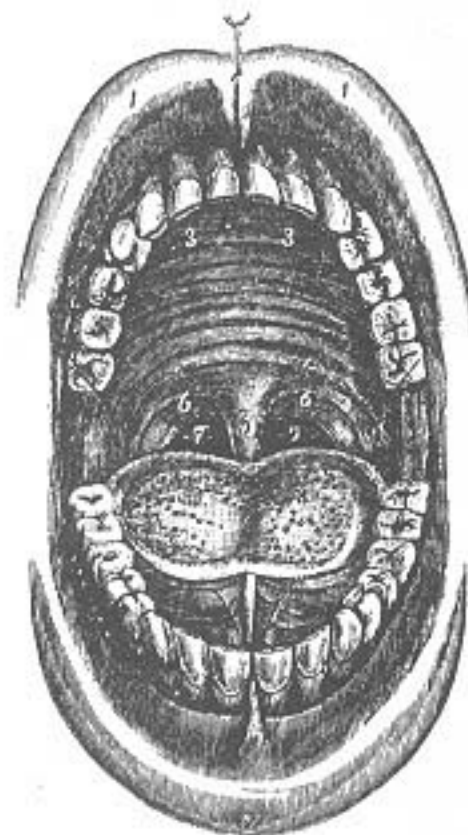
De la Rive and Marignac shortly afterwards, repeating the experiments of Van Marum, showed that electric sparks produce ozone even in pure and dry oxygen, and came to the conclusion that ozone is oxygen in an *allotropic* state, as diamond is a form of coke or charcoal. Baumert, in 1853, endeavoured to show that there are two kinds of ozone—one formed from pure oxygen by electric sparks, which he allowed to be *allotropic oxygen*; the other formed in the voltaic decomposition of water, which he endeavoured to prove to be a *teroxide* of hydrogen. Andrews, in 1856, refuted this view, by showing that no such oxide of hydrogen (at least in a gaseous form) is produced in the electrolysis of water; and that ozone, from whatever source obtained, is the same body, and is not a compound, but an *allotropic* form of oxygen.

In 1860 Andrews and Tait published the results of a series of *volumetric* experiments on this subject, which led to some remarkable conclusions—among which are the following: When the electric discharge is passed through pure oxygen it contracts, hence ozone must be denser than oxygen. A much greater amount of contraction, and a correspondingly greater quantity of ozone, are produced by a silent discharge of electricity between fine points than by a brilliant series of sparks. The contraction due to the formation of the ozone is entirely removed by the destruction of the ozone by heat; and this process can be repeated indefinitely on the same portion of oxygen.

Soret subsequently determined the density of ozone as compared with that of oxygen, first by absorbing the ozone from the oxygen with which it was mixed by means of oil of turpentine or oil of cinnamon, and observing the contraction produced; and later by determining the relative rates of diffusion of chlorine and ozone. He ascertained that its density is one and a half times that of oxygen. Andrews showed later that ozone is rapidly destroyed when shaken up with dry fragments of glass, &c. He also proved that the effect which is (almost invariably, and sometimes in fine weather powerfully) produced by the air on what are called ozone-test papers—papers steeped in iodide of potassium which are rendered brown by the liberation of iodine—is really due to ozone. He did so by showing that it acts upon mercury as ozone does, and that it is destroyed by heat at the same temperature.

The quantity of ozone in the atmosphere is never great, and it varies within wide limits. Little or nothing is known as to its function in the air, but it is believed to be active in destroying unwholesome substances, owing to its intensely oxidising properties. Ozone has been liquefied by the application of pressure, at a temperature of about -23° C. It is stated to be blue in the liquid state, and to be liable to decomposition into oxygen, with explosive violence, on sudden diminution of pressure.

Palate, the roof of the mouth, consists of two portions, the hard palate in front and the soft palate behind. The framework of the *hard palate* is formed by the intermaxillary bones, the palatine processes of the superior maxillary bones, and by the horizontal processes of the palatine bones, and is bounded in front and at the sides by the alveolar arches and gums, and posteriorly is continuous with the soft palate. It is covered by a dense structure formed by the periosteum and mucous membrane of the mouth, which are closely adherent. Along the middle line is a linear ridge or raphe, on either side of which the mucous membrane is thick, pale, and corrugated, while behind it is thin, of a darker tint, and smooth. This membrane is covered with scaly epithelium, and is furnished with numerous follicles (the palatine glands). The *soft palate* is a movable fold of mucous membrane enclosing muscular fibres, and suspended from the posterior border of the hard palate so to form an incomplete septum between the mouth and the pharynx; its sides being blended with the pharynx, while its lower border is free. When occupying its usual position (that is to say, when the muscular fibres contained in it are relaxed) its anterior surface is concave; and when its muscles are called into action, as in swallowing a morsel of food, it is raised and made



The Mouth widely opened so as to show the Palate :
1, 1, the upper, and 2, the lower lip; 3, 3, the hard palate;
4, 4, the soft palate; 5, the uvula; 6, 6, the arches of the soft
palate; 7, 7, the tonsils; 8, the tongue.

tense, and the food is thus prevented from passing into the posterior nares, and is at the same time directed obliquely backwards and downwards into the pharynx.

Hanging from the middle of its lower border is a small conical pendulous process, the *uvula*; and passing outwards from the uvula on each side are two curved folds of mucous membrane containing muscular fibres, and called the *arches* or *pillars* of the *soft palate*. The *anterior pillar* is continued downwards to the side of the base of the tongue. The *posterior pillar* is larger than the anterior, and runs downwards and backwards to the side of the pharynx. The anterior and posterior pillars are closely united above, but are separated below by an angular interval, in which the *tonsil* of either side is lodged. The tonsils (*amygdalæ*) are glandular organs of a rounded form, which vary considerably in size in different individuals. They are composed of an assemblage of mucous follicles, which secrete a thick grayish matter, and open on the surface of the gland by numerous (twelve to fifteen) orifices. The space left between the arches of the palate on the two sides is called the *isthmus* of the *fauces*. It is bounded above by the free margin of the palate, below by the tongue, and on each side by the pillars of the soft palate and tonsils.

As the upper lip may be fissured through imperfect development (in which case it presents the condition known as *Hare-lip*, q.v.), so also may there be more or less decided fissure of the palate. In the slightest form of this affection the uvula merely is fissured, while in extreme cases the cleft extends through both the soft and hard palate as far forward as the lips, and is then often combined with *hare-lip*. When the fissure is considerable it materially interferes with the acts of sucking and swallowing, and the infant runs a great risk of being starved; and if the child grows up its articulation is painfully indistinct. The closure of cleft palate by operation must be left in the hands of an experienced surgeon, who should be called to see the child as soon as the defect is noticed. If the separation is too great to admit of closure by operation, a plate or 'artificial palate' may be made to cover the opening.

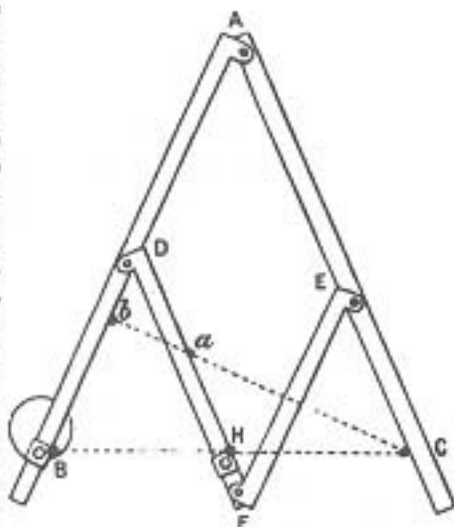
Acute inflammation of the tonsils, popularly known as *Quinsy*, is treated of in a separate article. Chronic enlargement of the tonsils is very frequent in scrofulous children, and is not rare in scrofulous persons of more advanced age, and may give rise to very considerable inconvenience and distress. It may occasion difficulty in swallowing, confused and inarticulate speech, deafness in various degrees from closure of the Eustachian tubes (now often termed *throat deafness*), and noisy and

laborious respiration, especially during sleep; and it may even cause death by suffocation, induced by the entanglement of viscid mucus between the enlarged glands. If local and constitutional remedies fail to reduce the enlarged tonsils they must be more or less removed by the surgeon, either by the knife or scissors, or by a small *guillotine* specially invented for the purpose.

Enlargement or relaxation of the uvula is not uncommon, and gives rise to a constant tickling cough and to expectoration, by the irritation of the larynx which it occasions. If it will not yield to local treatment it may require to be removed either in whole or in part.

Pantagraph, or **PANTOGRAPH** (Gr. *panta*, 'all'; *graphein*, 'to delineate'), an instrument invented for the purpose of making copies, reduced or enlarged, of drawings or plans. It is made in various

forms, one of which is shown in the figure. Four rods are so hinged to one another that AE is equal to DF, and AD to EF; hence ADFE is always a parallelogram. If from a given point C on AE any straight line BH (or *a*, *b*) be drawn, cutting the other arms, the triangle



ABC will always, no matter how the arms of the instrument be moved, be equal to the triangle DBH. It follows that, if the instrument be pivoted on a point at B (usually by a weight), a pencil-point inserted at H and a tracing-point at C, and the latter traced over the lines of a drawing, the pencil-point at H will trace a reduced copy of the drawing. The proportion of the reduction will be as BH is to BC. B and H are made to slide on their respective rods, so that any proportion of reduction can be made. By changing the places of the pencil and tracing-point, an enlarged copy may be made. The instrument is fitted with little castors to facilitate its free motion. The pantagraph was invented by the Jesuit-Christoph Scheiner prior to 1631, and improved by Professor W. Wallace of Edinburgh prior to 1831.

Enlargements or reductions can now be done so much more accurately by means of photography that the pantagraph is nearly obsolete.

Papier-mâché (Fr., 'mashed or pulp paper'). This name is applied to a material consisting either of paper-pulp or of sheets of paper pasted together, which by a peculiar treatment resembles varnished or lacquered wood in one class of articles made of it, and in another class (chiefly architectural ornaments) somewhat resembles plaster. Other substances are, however, mixed with paper, especially for the latter class of objects. Among eastern nations, where varnished and decorated articles in papier-mâché have long been made, the finest work has been produced in Persia, and next to it in Cashmere. The articles chiefly made are cases for pens and other writing materials, as well as boxes and trays. In Japan various objects are manufactured by gluing together a number of sheets of the soft and flexible paper of that country upon moulds, when it is in a damp state. This kind of papier-mâché, which is light, strong, and elastic, was at one time used in that country for helmets and other parts of armour. No doubt it was from one or other of these eastern countries that the art of working in papier-mâché was acquired by Europeans.

Articles of papier-mâché were extensively made in France in the first half of the 18th century. Subsequently the manufacture was largely developed in Germany. The painted papier-mâché snuff-boxes and other articles termed *Vernis Martin* work, from the fact that they were made by a coach-painter named Martin, who had a peculiar

way of varnishing them, were in the 18th century popular throughout Europe, and fine specimens are still sought after by collectors. Papier-mâché appears to have been introduced into England for the purpose of imitating Japanese trays of lacquered wood. In 1772 Henry Clay of Birmingham took out a patent for making papier-mâché of sheets of specially prepared paper pasted together upon a mould. In this way he produced panels for doors and walls, besides cabinets, screens, tables, tea-trays, &c., and these are still manufactured. The best papier-mâché is made by Clay's method; but it is also made from paper-pulp to which glue has been added, and this is pressed between dies to give it the required shape. There is a third kind made of coarse fibrous material, mixed with earthy matters and a binding size, certain chemicals being added to render it incombustible. Suppose that a tray-blank of pasted sheets has been formed upon a metal mould. It is then heated to 120° F., and afterwards dipped in a mixture of linseed-oil and spirits of tar (other mixtures are used) to harden it and make it resist moisture. It is again placed in a stove, and when taken out it is planed and filed to give it the required finish. The tray now gets several coats of tar varnish and lampblack, each of which is rubbed down with pumice, and stoved once more. It is then ready to be decorated, after which it receives a coat of transparent varnish, and is finally polished with the hand.

Carton-pierre, which has been extensively employed for the internal decoration of buildings (much in the same way as plaster), is formed of paper-pulp mixed with whiting and glue, and pressed into plaster moulds. It is next backed with paper, allowed to set, and dried in a hot room. **Ceramic Papier-mâché** (Martin's patent dated March 15, 1858) is a very plastic substance, which can be readily moulded or otherwise worked into any required form. It is composed of paper-pulp, resin, glue, drying oil, and sugar of lead, well kneaded together.

There are various ways of decorating papier-mâché. For tea-trays, caskets, panels, and other objects with a black varnished surface, what is called 'inlaying' with plates of mother-of-pearl shell, scarcely thicker than stout writing-paper, has been largely practised. The pieces of shell are stuck on with varnish, and the design painted on them with a protecting varnish. An application

of acid dissolves away the unprotected parts, and then the interspaces are filled up with varnish. When the surface is rubbed with pumice-stone the superfluous varnish is removed, and the shell ornaments displayed. In a similar way the surface can be 'inlaid' with cut-out metal devices. Flower and landscape painting has also been much employed in the way of decoration, as well as borders and other ornaments in leaf gold. Owing to the extensive importation in recent years of cheap Japanese lacquer wares (see LACQUER), the Birmingham manufacturers of papier-mâché have now largely resorted to an inexpensive decoration by transfer-printing, which can be done by boys and girls instead of highly-paid artists. A change has also taken place in the nature of the material itself, which has recently been chiefly made of wood-pulp from Sweden. A limited quantity of the old high-class papier-mâché is, however, still regularly manufactured. The variety of papier-mâché adopted for architectural ornaments, which are usually more or less in relief, can be readily painted, gilded, or bronzed. The application of papier-mâché to articles requiring great strength, such as wheels for railway carriages, has not proved so successful as was at one time anticipated.

Parchment (Fr. *parchemin*, Lat. *pergamena*, through Gr. from *Pergamus*). At a very early period the skins of animals were used for writing upon. Some authors who have written on the subject of ancient writing materials think that the king of Pergamos brought the art of making parchment to perfection through Ptolemy Epiphanes having prohibited the exportation of papyrus from Egypt. The Romans appear to have written chiefly on papyrus, and this practice was continued in Italy till about the 10th century, but parchment was also used; and from that time till ordinary paper became available in the 14th century parchment was almost the only material employed.

To a limited extent wax-tablets and leaden plates were written upon as late as the 14th and 15th centuries, and some of these are

preserved at Florence. Some of the earliest printed books were done on vellum (a name originally given to a parchment made of calf-skin), and on a specially fine quality of this substance, made from the skins of calves prematurely born, some of the best of the early miniature portraits were painted. Ordinary parchment is chiefly made of sheep-skins, but those of calves and goats are also used. Fine parchment and vellum are prepared from the skins of kids, lambs, and young calves. A coarser parchment for drumheads, tambourines, &c. is manufactured from the skins of male goats, wolves, and calves. A peculiar kind is made from asses' skin, and for bookbinders' use a parchment is sometimes prepared from pig-skin. The early stages in the manufacture of parchment are the same as for Leather (q.v.). After being unhaired and cleaned, the skins are stretched evenly upon a stout wooden frame called a *horse*. The flesh side of the skin is first gone over with a double-edged semicircular knife (fleshing-tool) to remove adhering particles of flesh. With the fleshing-tool inverted, to prevent any cutting of the epidermis, the other side of the skin is then scraped to remove dirt and to squeeze out some of the absorbed water. For some purposes for which stout parchment is required the skin is now merely allowed to dry on the frame, no further treatment being required. But fine parchment for writing or drawing upon, some of which is made from split skins, is sprinkled over with sifted chalk on the flesh side and rubbed smooth with a flat surface of pumice-stone. The grain side of the skin also is rubbed over with pumice, but no chalk is used. In these operations great care requires to be taken not to fray the surface, and certain precautions are necessary during the drying of the parchment. Any considerable roughness or unequal thickness is removed by the skin being again scraped and pumiced.

VEGETABLE PARCHMENT.—This substance, which excited much interest and curiosity when it was first introduced, was patented by Mr W. E. Gaine in 1853 (no. of specification, 2834). It is made by dipping ordinary unsized paper for a few seconds in concentrated sulphuric acid mixed with one-half its volume of water, and then quickly removing all trace of the acid. The mixture is allowed to cool before being used. This simple treatment produces a remarkable change in the paper. It acquires a parchment-like texture; turns translucent, especially when thin; and becomes about five times stronger than ordinary paper. Vegetable parchment is also impervious to water, but is rendered soft and limp when dipped into it. The acid produces a molecular change in the Cellulose (q.v.) of which paper consists. A solution of chloride of zinc acts on paper in a similar way. In the manufacture of vegetable parchment a roll of paper is by a mechanical arrangement pulled through a vat containing the sulphuric acid (the time of immersion being from five to ten seconds for thin paper), next through water, then through a weak solution of ammonia, and once more through water. It is afterwards passed through felt-covered rollers, and then calendered. Stout qualities of vegetable parchment have been used for book-covers and for writing deeds upon. Thin sheets of it serve as a convenient material for tracing designs, plans, &c. But it is now chiefly employed for covering jars of preserves and for like purposes.

Paregoric, or **PAREGORIC ELIXIR** (from the Gr. *parégoricos*, 'soothing'), the *Compound Tincture of Camphor* of the British Pharmacopœia, consists of an alcoholic solution of opium, benzoic acid, camphor, and oil of anise, every fluid ounce containing 2 grains each of opium and benzoic acid, and 1½ grains of camphor. This preparation is much used both by the profession and the public. In doses of from 30 to 60 drops it is an excellent remedy for the chronic winter-cough of old people, the opium diminishing the bronchial secretion and the sensibility of the pulmonary mucous membrane, while the benzoic acid and oil of anise act as stimulating expectorants. It has also been found useful in chronic rheumatism, and, especially in the case of children, to relieve slight pains in the stomach and bowels.

Passionflower (*Passiflora*), a genus of plants almost exclusively natives of the warm parts of America, and belonging to the natural order Passifloraceæ. The flowers are hermaphrodite, with a

coloured calyx, generally of five segments; the corolla also of five segments or wanting; always having a more or less conspicuous crown of filaments springing from the throat of the tube formed by the base of the calyx and corolla. The stamens are five, inserted in the tube of the calyx, united in a tube to near the apex, where they divide, and are surmounted by the much-reflexed anthers. The ovary is one-celled, elevated on a stalk, surmounted by three thick styles with thick clove-like stigmas. The fruit is fleshy. This genus has received its name from fanciful persons among the first Spanish settlers in America imagining that they saw in its flowers the emblems of our Lord's passion; the filamentous processes being taken to represent the crown of thorns, the nail-shaped styles the nails of the cross, and the five anthers the marks of the wounds. The species are mostly half-shrubby evergreen or stove climbers, of rapid growth; and most of them have lobed leaves, with from two to seven lobes. The flowers of many are large and beautiful, on which account they are often cultivated in hothouses. Some of the species are also cultivated in tropical countries for their fruit, particularly those of which the fruit is known by the name Granadilla (q.v.). The apple-fruited Granadilla or Sweet Calabash of the West Indies is the fruit of *P. maliformis*, which is about two inches in diameter, containing within a hard stringy shell an agreeable gelatinous pale yellow pulp. *P. quadrangularis* is the common Granadilla, a native of Jamaica and South America, but is cultivated in all parts of tropical South America, and occasionally in hot-houses in Britain for the sake of its fruit. The fruit is oblong in shape, often six inches in diameter transversely. The skin when ripe is greenish yellow in colour, thin, but tough and leathery, and contains a very succulent pulp of a purple colour which is sweet and slightly acid. It is generally eaten with wine and sugar. The root of the plant is poisonous, owing to the presence of an active principle called *passiflorine*, the properties of which are similar to morphine. The laurel-leaved Granadilla is *P. laurifolia*, the fruit of which is named *Water-lemon* by the English and *Pomme de Liane* by the French in the West India Islands. It grows to about the size of a hen's egg, becomes yellow, dotted over with white when ripe, and contains within the tough thin rind a whitish sweet watery pulp, delicately aromatic and slightly acid. It quenches thirst, allays heat, and induces appetite. *P. incarnata*, a species with herbaceous stems, a native of the warm parts of South America, produces an edible orange-coloured fruit about the size of an ordinary apple. The fruit of *P. edulis* is about two inches long and slightly less in diameter, assuming a livid purple colour when ripe, and contains an orange-coloured pulp with the flavour of a somewhat acid orange. The fruit of some species of passionflower, however, is not only uneatable, but fetid; and the roots, leaves, and flowers of some have medicinal properties, narcotic, emmenagogue, anthelmintic, febrifugal, &c. The hardiest species, the Blue Passionflower (*P. cerulea*), grows well enough in some parts of France, and even in the south of England.



Passionflower (*Passiflora caerulea*).

Pastille (diminutive of paste) originally applied to lozenges as little portions of confectionery paste, but it has been of late chiefly confined to a mixture of odorous materials, as in the case of the *fumigating pastilles*, which are burned either as incense or as a means of diffusing an agreeable odour. They are composed of charcoal powder, with such aromatic gums as benzoin, ladanum, &c., and powders of sweet-scented woods and barks, as sandalwood, cinnamon, and especially cascarilla

barks. Essential oils are also added, and the whole are worked into a paste with a little gum-mucilage, and formed into small sharp-pointed cones about an inch and a half high, and half an inch broad at the base. When perfectly dry they are used by lighting at the point, and as they burn down an agreeable odour is given out with the smoke. Another kind of pastille, usually in the form of a small pill covered with gold or silver leaf, is used for perfuming the breath; it is made of similar ingredients, excepting the charcoal.

Patchouli, a perfume derived from the dried branches of *Pogostemon patchouli* (natural order Labiate), first introduced into Britain as an article of merchandise in 1844. The name is from the Tamil *patchei*, 'gum,' and *elei*, 'leaf.' The plant, a low shrub 2½ or 3 feet high, is a native of Silhet, the Malay coast, Ceylon, Java, the neighbourhood of Bombay, and probably also of China; but, owing to the fondness of Asiatics for the perfume which it yields, it is difficult to say where it is native or cultivated. Every part of the plant is odoriferous, but the younger portions of the branches with the leaves are chosen; they are usually about a foot long. The odour is peculiar and difficult to define, but it has a slight resemblance to sandalwood; it is very powerful, and to many persons is extremely disagreeable. The odour of patchouli was known in Europe before the material itself was introduced, in consequence of its use in Cashmere to scent the shawls with a view of keeping out moths, which are averse to it; hence the genuine Cashmere shawls were known by their scent, until the French found the secret, and imported the herb for use in the same way. In India it is used as an ingredient in fancy tobaccos and as a perfume for the hair. It is also much prized for keeping insects from linen and woollen articles. The essence of patchouli is a peculiar heavy brown oil, with a disagreeably powerful odour; it is obtained by distillation, and requires extreme dilution for perfumery purposes. A cwt. of the plant yields about 28 oz. of the oil. The Arabs believe it to be efficacious in preventing contagion and prolonging life.



Peasant Proprietorship is a system of cultivation of small holdings of land by occupiers who own the land, or hold it on some secure or permanent tenure. Perhaps there is no question on which there is a greater diversity of opinion. On the one hand the small cultivator is held up as a pattern of industry, thrift, and prosperity, and on the other as an example of unceasing toil and miserable failure.

Arthur Young held that the best system of agriculture was that which secured the largest amount of produce from the land. It is evident, however, that another consideration of great importance must be taken into account—viz. the numbers, quality, and condition of those engaged in tilling the soil. Though nations might attain to brilliant positions by trade, commerce, and the accumulation of wealth, yet the permanent strength, the solidity, and resisting power of a country must closely depend on the number and condition of its rural population. Hence if it could be proved that vast areas of land could be cultivated at the greatest money profit, by means of machinery and a handful of labourers, yet such a method of cultivation would be adverse to the real interests of the nation as a whole.

There is substantial evidence, however, that small holdings of land are more productive in proportion than large farms, and that they are specially adapted to the production of certain kinds of food. It is from these causes that the rent value and purchase price of the smaller holdings in continental countries are so much higher than are found to obtain with the larger farms of Great Britain. It is frequently quoted in opposition to this view that the yield of corn per acre is much greater in England than on the Continent. This comparison, however, is of little value from the fact that the average of continental production is much lowered through the low yields of poor land, hillsides, and wastes, which, if in England, would not be cultivated at all. The evidence of the Royal Commission on Agriculture (1880) shows that the vast majority of holdings in the Netherlands are from 10

to 60 acres, held for the most part by cultivating owners, and that the small and medium-sized farms are generally the best cultivated and managed. Mr Jenkins, the assistant commissioner, gave many examples of what he terms 'intensive' cultivation in Holland. One of these is that of a man who owned 22 acres of land, and rented 10 acres more. He had thirty milking cows in the fields, and ten feeding beasts in the stall. He fed every year thirty beasts besides his own cast cows, and spent above £600 per annum for food, principally for winter keep.

Belgium is rather a country of small cultivators than of peasant proprietors. If we leave out of account the owners of very small plots of land, it is the small tenant-farmer who is the most important element in Belgian agriculture. In spite, however, of excessive rents, the insecurity and other drawbacks of tenancies as compared with ownership, Belgium is a striking example of the advantages of *la petite culture*. M. de Laveleye states that Belgium is the best cultivated and the most productive country in the world; and refers to Flanders, with land naturally the worst in Europe, as a marvellous triumph of care, industry, and forethought on the part of the cultivators. According to the report above quoted, the available supply of milk and its products per head of the population is in Belgium about twice as great as that in Great Britain. In most districts in Belgium the labourer is a *petit cultivateur*—i.e. while hiring himself out as a labourer, he cultivates and often owns a piece of land stocked with rabbits, pigs, poultry, goats, and sometimes one or a couple of cows. A man of this class in the Ardennes, who was working with his son for a farmer at five francs per day, was found on inquiry by the present writer to be the owner of a cottage with 6 acres of land, two cows, and other smaller stock. This man is a type of a most numerous class whose aim is to become small farmers, and who, with that end in view, work hard and practise the severest thrift and perseverance.

In Great Britain the amount of stock per acre carried on small holdings is larger—with the exception of sheep—than that carried on a similar area of land in large farms. Tables compiled by the writer from the agricultural returns of Great Britain, and printed in the evidence given before the Select Committee on Small Holdings (1889), show that the area of land in Great Britain cultivated in small holdings of 1 acre to 100 acres is about the same as the area cultivated in large farms of 300 acres and upwards, the area being about 9½ and 9¼ million acres respectively. The tables show that the small holdings carry 511,038 horses, the large farms 314,016; cows and other cattle 2,660,281 as against 1,227,904; pigs 1,178,500 as against 383,626. Only in sheep is the advantage shown to be with the large farms. It frequently happens that cases showing the failure of *petite culture* refer really to small cultivators who hold their land on a yearly tenancy or some other uncertain tenure, a class altogether distinct from and lacking the essential conditions of peasant proprietors. The great prosperity of agriculture in Denmark, and the large and increasing exports of butter, eggs, cattle, pigs, &c. from that country are due to the fact that the great bulk of the land is cultivated by owners, mainly by peasant proprietors of farms from 25 to 125 acres. Mr Jenkins gives interesting examples, not exceptional, of prosperous highly cultivated peasant farms in Denmark. One small owner of 50 acres of land kept eighteen cows, fed eighteen pigs annually, and had two horses to work the arable land. The whole family was employed on the farm or in the dairy. The dairy, though small, 12 by 14 feet, was a perfect sight for order, cleanliness, and for the complete though inexpensive character of the arrangements and appliances. The majority of the agricultural labourers in Denmark possess a cottage with a few acres of land, either his own or on lease. In Germany the agrarian reforms inaugurated by Stein and Hardenberg early in the 19th century, and continued up to recent date, for the promotion of cultivating ownership in land, were undoubtedly the groundwork of the strength and solidity of the German nation.

In direct connection with the subject of peasant proprietorship is the fact of Britain's great and increasing dependence on foreign countries for a supply of the smaller articles of food. Besides fruit, vegetables, honey, flowers, &c., the importation of which is yearly increasing, the value of the following articles in pounds sterling imported in 1889 was as follows:

Cheese above $4\frac{1}{2}$ million; butter above $10\frac{1}{2}$ million; margarine above $3\frac{1}{2}$ million; lard above 2 million; poultry, game, and rabbits above $3\frac{1}{2}$ million; bacon and hams above $9\frac{1}{2}$ million; pork, potatoes, and onions above 2 million; eggs above 3 million. This gives the enormous aggregate value of 36 million sterling paid annually to the foreigner for these smaller articles of food, for the production of which the soil and climate of England are for the most part specially fitted. In the face of chronic complaints of agricultural depression, this great volume of trade is allowed to pass into the hands of the small cultivator abroad. The reason is that the system of large farming is not adapted to the supply of these articles. The large farmer who raises corn and cattle cannot successfully compete with the small grower who is accustomed to minute and intensive cultivation. Peasant proprietorship is a separate and distinct business. The conditions of its success are close personal attention, hard work, and the strictest frugality. The peasant cultivator employs but little hired labour, every member of the family doing something useful on the little holding. The system develops a handiness, a fertility of resources, an adaptation of means to ends, and an incessant industry, qualities hardly to be expected in connection with hired labour. As owner of his little holding the peasant proprietor has no restrictions as to cropping or methods of cultivation. He has no doubts about compensation for unexhausted manures and improvements, and no uncertainty as to tenure. As a small owner who for many years has lived on and successfully cultivated a few acres of land remarked to the present writer—'The more I care for and work my land the more it gives me back; my little farm is my bank in which I put my labour and savings, which it pays me back with good interest.' It is often said that thrift, prudence, and perseverance are peculiar to the peasant proprietor on the Continent, and are the cause of his success. The history of peasant proprietorship, however, shows that these qualities are the result and not the cause of cultivating ownership. Improvident habits, early marriages, and little thought for the morrow are the too frequent accompaniments of a condition in which there is no prospect in life beyond that of a mere wage-receiver. The great secret of success of peasant proprietorship is summed up by Adam Smith in a striking passage in his *Wealth of Nations*: 'A small proprietor who knows every part of his little territory, who views it with all the affection which property, especially small property, naturally inspires, and who upon that account takes pleasure not only in cultivating but in adorning it, is generally of all improves the most industrious, the most intelligent, and the most successful.' The two great drawbacks of peasant proprietorship are excessive subdivision and the unlimited power of mortgage. The land-hunger—especially in France—is so great that the proprietor of a few acres will submit to any privation to save money, and will borrow at any rate, in order to acquire more land. The money-lender on the Continent, like the 'gombeen' man in Ireland, is the chief cause of trouble and difficulty to the small cultivator. The creation of a peasant proprietorship in Great Britain, though much discussed, has not till recently been seriously entertained as a practical question. In 1889 the government appointed a Select Committee on Small Holdings, and the evidence contains practical information on the various aspects of peasant proprietorship, and on the applicability of the system to Great Britain. The committee in their Report (1890) unanimously recommend that facilities should be given for the creation of small holdings, and they adopt the principles of Mr Jesse Collings' Small Holdings Bill. The general provisions of this bill are as follows: Local authorities are empowered by moneys borrowed for that purpose from the state, to acquire land and to sell the same in small holdings not exceeding 50 acres each. Purchasers are required to pay down as proof of their *bona fides* a portion not exceeding one-fourth or one-fifth of the purchase-money. A part of the balance is to be paid off by annual payments, but the remainder—a small proportion of the original cost—is to remain at a perpetual feu or quit-rent. This provision, while it protects the small holder—to a great extent—from the money-lender, at the same time makes the terms of purchase as easy as possible. It also enables the local authority to enforce the conditions provided against subletting and subdivision. The local authorities are further empowered to let land on favourable conditions in small holdings not exceeding 10 acres each. The report of the Select

Committee declares that the extension of small ownerships 'is a matter of national importance both in the interests of the rural population, and also as adding to the security of property generally. The committee recommend that a sum not exceeding in the first instance five millions sterling should be devoted to the experiment, and earnestly hope that no time will be lost in introducing legislation to give effect to their recommendations.' This report, followed by the announcement of legislation on the subject in the Queen's speech of 1890, and the acceptance by the government in 1891 of the second reading of the Small Holdings Bill referred to, may together be taken as the first practical steps towards the creation of a peasant proprietorship in Great Britain.

Peat, a substance formed by the decomposition of plants amidst much moisture, as in marshes and morasses, and sometimes described as a kind of humus or soil, formed by the accumulation of the remains of mosses and other marsh-plants. The remains of the plants are often so well preserved in it that the species can be easily distinguished. Reeds, rushes, and other aquatic plants may usually be traced in peat, and stems of heath are often abundant in it; but it chiefly consists in the northern parts of the world of different species of *Sphagnum* or Bog-moss (see BOG-PLANTS). Mosses of this genus grow in very wet situations, and throw out new shoots in their upper parts whilst their lower parts are decaying and being converted into peat; so that shallow pools are gradually changed into bogs. Stools and trunks of trees often occur under peat in the British Islands and in north-western Europe generally. And not only so, but similar stools and trunks frequently are met with occupying a middle position in many peat-bogs—i.e. resting on peat and covered by a variable thickness of the same accumulation. It cannot be doubted that the overturning of trees, whether by natural causes or by man's hand, would in many cases impede surface drainage, and so eventually give rise to the formation of bogs. But there is reason to suspect that the succession of 'buried forests' and peat so frequently seen in the bogs of north-western Europe points to climatic changes (see POST-GLACIAL SYSTEM). Peat is vegetable matter more or less decomposed, and passes by insensible degrees into Lignite (q.v.). The less perfectly decomposed peat is generally of a brown colour; that which is more perfectly decomposed is often nearly black. Moist peat possesses a decided and powerful antiseptic property, which is attributed to the presence of gallic acid and tannin, and is manifested in the perfect preservation not only of ancient trees and of leaves, fruits, &c., but sometimes even of animal bodies. Thus, in some instances human bodies have been found perfectly preserved in peat after the lapse of centuries.

The formation of peat takes place only in the colder parts of the world. In warm regions the decay of vegetable substances after life has ceased is too rapid. The surface covered by peat is very extensive in all temperate regions. In England it is considerable; it is greater in Scotland, and very great in Ireland. Some large peat-bogs occur in the south of Europe, even near the sea, and in more northern regions the mosses or bogs are still more extensive; they occur also in the northern United States, but more extensively in Canada and Newfoundland. For their physical characters and the mode of reclaiming them, see BOG, and WASTE LANDS. Mere peat is not a good soil, even when sufficiently drained, but by the application of lime, marl, &c. it is soon converted into valuable land, yielding excellent crops. A mixture of peat is often of benefit to soils otherwise poor; and for many shrubs, as rhododendrons, kalmias, whortleberries, &c., no soil is so suitable as one largely composed of peat.

Peat is the ordinary fuel of great part of Ireland, and is still much in request in the hillier parts of Scotland and England. In Holland, Denmark, and parts of north Germany it is also in use for the same purpose. Peat is a light and bulky kind of fuel, and cannot be conveyed to considerable distances without too great expense. Efforts have, however, been made to render it more generally useful, and so to promote the reclaiming of bogs, by compressing it until its specific gravity is nearly equal to that of coal. For this purpose it is first reduced to a pulp. But the process has not yet been advantageously prosecuted on an extensive

scale, though numerous machines for the purpose have been patented in Germany and in the United States. Peat-charcoal, made from uncompressed peat, is very light and inflammable, and therefore unsuitable for many purposes, but for others it is particularly adapted, and no kind of charcoal excels it in antiseptic and deodorising properties. Peat-charcoal is highly esteemed for the smelting of iron and for working and tempering the finer kinds of cutlery. Charcoal made from compressed peat is in density superior to wood-charcoal, and is capable of being used as coke. But the conversion of peat into charcoal has not proved remunerative; and the attempts to obtain valuable products (pyroligneous acid, ammonia, inflammable oils, burning gas, tar, &c.) from its destructive distillation have been similarly unsuccessful.

Peat, specially prepared, is very serviceable for horses' bedding, &c. As antiseptic, it has been used for laying on wounds. Flower-pots are sometimes made of peat; it is easy to transplant flowers growing in them without loosening the earth from the roots, the pot being readily cut to pieces; and liquid manure applied outside finds its way to the roots.

Pelvis. This term is used to indicate one of the chief divisions of the skeleton. It consists of the sacrum, coccyx, and the innominate or haunch bones. Each of the latter originally consisted of three parts—ilium, ischium, pubis—which have become fused together. By the articulation of the pubic bones in the middle line anteriorly the innominate bones form the anterior and lateral aspects of the pelvis. Wedged in between them posteriorly are the sacrum and coccyx. Various powerful ligaments give support to and maintain the pelvic bones in position. Notwithstanding the importance of this part of the skeleton, the ancient Greek physician had no word whereby to designate it, and both Greek and Roman associated the sacrum and coccyx with the vertebral column, and the innominate bones with the lower extremities.

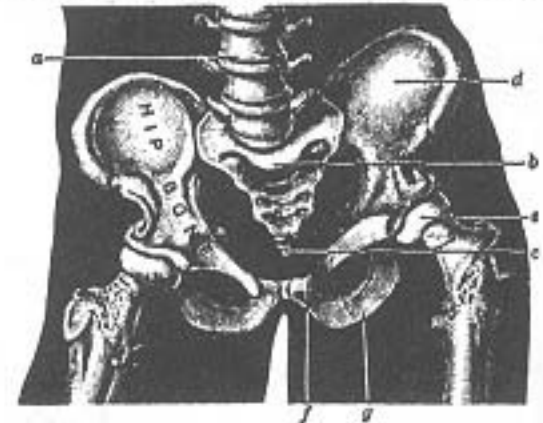


Fig. 1.—Adult Human Pelvis, in situ:

a, lumbar vertebra; b, sacrum; c, coccyx; d, ilium; e, head of femur in acetabulum; f, pubis; g, ischium.

The pelvis is divided into two parts by a plane which extends from the upper margin or promontory of the sacrum to the upper margin of the articulation between the two pubic bones—i.e. the symphysis pubis. On the inner surface of each innominate bone a line may be traced from the sacral promontory to the symphysis pubis. This is named the ilio-pectineal line, and it helps to complete the circumference of the plane which divides the pelvis into two parts. The space above this plane lies mostly between the expanded iliac bones. It belongs to the abdomen proper, and is named the *false pelvis*. The space below the level of the sacral promontory and ilio-pectineal lines is called the *true pelvis*, and certain descriptive terms are employed in connection with it. Thus the plane which separates it from the false pelvis is called the *inlet* or *brim* of the true pelvis. Its inferior circumference or *outlet* extends from the tip of the coccyx to the inferior border of the pubic symphysis, and from the one ischial tuberosity to the other. Between the ischial tuberosities in front and extending forwards to the symphysis there is the *subpubic arch*. The space between the *inlet* and the *outlet* is named the *cavity* of the true pelvis. The measurements of the true pelvis are made along certain definite lines which are applicable to the brim, the cavity, or the outlet. These are (1) the *antero-posterior* or *conjugate diameter*—i.e. from the mesial line in front to the mesial line behind; (2) the *transverse* or *widest diameter*; (3) the *oblique diameters*—right and left. These extend

from the articulation between sacrum and ilium on one side to the farthest point on the opposite side of the mesial plane. In the erect attitude of the body the plane of the brim of the true pelvis forms an angle with the horizontal which varies from 60° to 65°. Thus the weight of the upper part of the body which is communicated to the sacrum is directed downwards and transmitted through the innominate bones to the heads of the femora, and so to the inferior extremities. In addition to the ligaments, muscles, blood-vessels, and nerves which constitute the soft parts of the pelvis, there are certain special organs which are present in both sexes, and others which are peculiar to each sex.

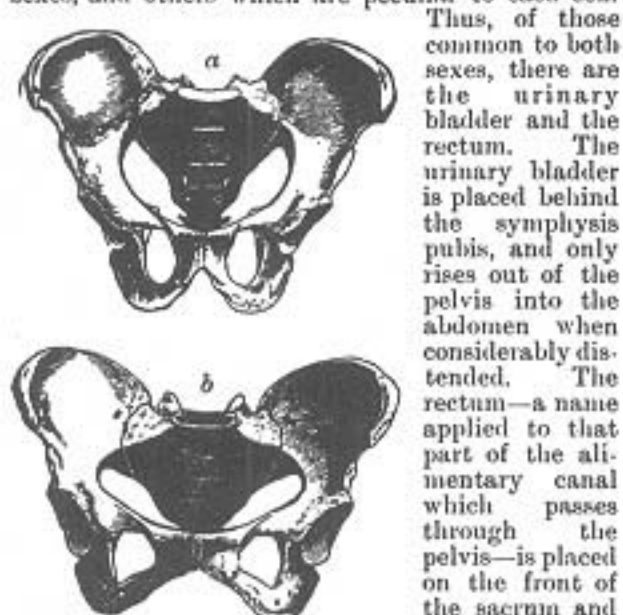


Fig. 2.

a, adult male, and b, female pelvis.

Thus, of those common to both sexes, there are the urinary bladder and the rectum. The urinary bladder is placed behind the symphysis pubis, and only rises out of the pelvis into the abdomen when considerably distended. The rectum—a name applied to that part of the alimentary canal which passes through the pelvis—is placed on the front of the sacrum and coccyx, a short distance below which it terminates in the anus. The lower end of the rectum is supported by two muscles—the *levator ani*—which surround it so completely as to form a floor or diaphragm for the pelvis. In addition to these organs there are others which are characteristic of the sexes. In the male we have the *vesiculae seminales* and the *prostate gland*—the latter surrounding the outlet of the urinary bladder. In the female we have the *uterus*, *ovaries*, and their various appendages. The diverse functions of these organs have led to corresponding and well-marked differences in the size and form of the osseous pelves of the sexes. In the female the bones are more slender, and the muscular impressions less distinct. The true pelvis has a greater breadth and capacity, but its perpendicular depth is less. The *inlet* is more nearly circular; the ischial tuberosities are wider apart, and the subpubic arch is much wider. All of these differences indicate special modifications in connection with the necessities of child-bearing. Although the depth of the cavity of the true pelvis steadily increases from childhood to puberty, yet the characteristics of the sexes are discernible even at birth.

But not only does the pelvis display features which are characteristic of sex; it also presents characters which are peculiar to individual races of mankind. In this field of study a great amount of valuable work has been contributed by Sir William Turner of Edinburgh University, and embodied in the reports of the *Challenger* expedition. In determining those features peculiar to race numerous measurements have been made, mostly in relation to the cavity of the true pelvis with its brim and outlet; but many of the external dimensions of the entire pelvis have also been noted, as well as the dimensions of individual bones. One of the most valuable of the external measurements is the comparison between the maximum height and breadth of the entire pelvis. A common result is obtained by the following formula, $\frac{\text{height} \times 100}{\text{breadth}}$, which establishes what is called a *breadth-height index*. Another index of great importance is the result of a comparison between the *conjugate* and *transverse* diameters at the brim of the pelvis. This is named the *pelvic or brim index*, and is obtained by the formula, $\frac{\text{conj. diam.} \times 100}{\text{transverse diam.}}$. The measurements are usually recorded in millimetres. As the result of numerous measurements Sir William Turner has devised a classification of pelves based upon the relation of the conjugate and transverse diameters at the brim of the true pelvis—i.e. upon the *brim index*. Thus, those pelves in

which the conjugate diameter of the brim is either longer than the transverse or closely approaches it are named *dolichopellic* (*pellis*, the Greek equivalent of the Latin *pelvis*, 'a basin'; and *dolichos*, 'long'), and in these the brim index is above 95. When the transverse diameter of the brim greatly exceeds the conjugate they are named *platypellic* (*platys*, 'wide'), and the brim index is below 90. In cases where the transverse diameter is not greatly in excess of the conjugate—i.e. where the brim index varies between 90 and 95, both inclusive—the term *mesatipellic* (*mesaitatos*, 'middlemost') is applied. Grouping the pelves under these headings we find that such races as Australians, Bushmen, Hottentots, Kaffirs, Malays, Andaman Islanders, &c. are *dolichopellic*. Negroes, Tasmanians, New Caledonians, &c. are *mesatipellic*. British, French, Germans, Europeans generally, natives of India, Chinese, American Indians, &c. are *platypellic*. These results are obtained from the examination of male pelves, since, as we have already seen, the female pelvis is modified in its diameters in relation to the special requirements of sex.

If now we compare the human pelvis with that of the lower mammalia, we shall find that the human pelvis is characterised by breadth and shallowness and the great capacity of the true pelvis. When, therefore, the conjugate diameter at the brim of the pelvis is longer than the transverse—i.e. when the pelvis is *dolichopellic*—an approach is made to the condition which prevails even to a greater extent among the lower animals, and it is 'a degraded or animalised arrangement' as compared with *platypellic* pelvis of Europeans.

We have seen that in man the weight of the trunk is transmitted to the lower limbs through the pelvis, whereas in quadrupeds the downward pressure of the weight of the trunk is differently disposed. Doubtless, therefore, the *attitude* has great influence in controlling the expansion of the pelvis in the transverse diameter when the parts are young and plastic. It may therefore be owing to the habits and mode of life of the black races in their aboriginal state that their pelves approach the lower type. Take, for example, the aboriginal Australian who sits on the ground embracing his knees with his arms, or any of the savages whose favourite attitude is 'squatting'—i.e. sitting down with the body bent forward and the buttocks resting on the heels; or again, when in pursuit of game a stooping or crouching attitude is adopted. In all these positions the pressure upon the sacrum and pelvis is diminished, and there is a tendency to approximate the conditions to those of the anthropoid apes, while the white man on the other hand preserves the erect attitude whether standing, sitting, or walking.

Pemmican. This was originally a North American Indian preparation only, but it was introduced into the British navy victualling-yards in order to supply arctic expeditions with an easily-preserved food, containing the largest amount of nutriment in the smallest space. As made by the Indians, it consists of the lean portions of venison dried in the sun, or wind, and then pounded into a paste and tightly pressed into cakes; sometimes a few fruits of *Amelanchier ovata* are added to improve the flavour. It will keep for a very long time uninjured. That made for the arctic voyagers was chiefly of beef. In making pemmican it is necessary to remove the fat completely.

Pennyroyal (*Mentha pulegium*), a species of Mint (q.v.), a native of Europe and western Asia, abundant in England and in some parts of Ireland, not found wild in Scotland, though sometimes grown there in gardens for its reputed medicinal qualities. It enjoys a high popular reputation as an emmenagogue, but no dependence may be placed in its efficacy. The name pennyroyal is given in North America to a small plant, *Hedeoma pulegioides*, allied to the mints, and having,

Pennyroyal (*Mentha pulegium*).

like them, a pleasant aromatic smell and a warm pungent taste. It is much in use in domestic medicine, in the form of a warm infusion, to promote perspiration and as an emmenagogue.

Perfumery. Perfumes are of two distinct classes—those derived from plants and those which are of animal origin.

Vegetable Perfumes.—The most ancient of the so-called primary odoriferous bodies are the so-called gum-resins which exude naturally from the trees which yield them, or from wounds accidental or purposely inflicted to increase the yield. The most important are benzoin, myrrh, opoponax, tolu, Peru, and storax. Gum-resins form the chief ingredients in 'Incense' (q.v.) and Pastilles (q.v.).

A second group is that large class of perfumes which are procured by distillation, and are mostly fluid bodies, and are termed Volatile Oils, Essential Oils, or Ottos—formerly Quintessences (see OILS). As soon as the Greeks and the Romans learned the use of the still, which was an invention imported by them from Egypt, they quickly adapted it to the separation of the odorous principle from the numerous fragrant plants indigenous to Greece and Italy. Long before that time, however, fragrant waters were in use in Arabia. Odour-bearing plants contain the fragrant principle in minute glands or sacs; these are found sometimes in the rind of the fruit, as the lemon and orange; in others it is in the leaves, as sage, mint, and thyme; in wood, as rose-wood and sandalwood; in the bark, as cassia and cinnamon; in seeds, as caraway and nutmeg; in yet others in the petals, as in rose, lavender, or Ilang-Ylang. The odour principle of orris is a solid resembling cocoa-butter, and is contained in what is really the rhizome of *Iris florentina*, though technically called orris-root. These glands or bags of fragrance may be plainly seen in a thin-cut stratum of orange-peel; so also in a bay leaf, if it be held up to the sunlight, all the oil-cells may be seen like specks. All the fragrance-bearing substances yield by distillation an essential oil peculiar to each; thus is procured oil of patchouli from the leaves of the patchouli plant, *Pogostemon patchouli*, a native of Burma; oil of caraway, from the caraway-seed; oil of geranium, from the leaves of the *Pelargonium roseum*; oil of lemon, from lemon-peel, *Citrus limonis*; and a hundred of others of infinite variety.

All the various essential oils or ottos are very slightly soluble in water, so that in the process of distillation the water which comes over is always fragrant. Thus, elder-water, rose-water, orange-water, dill-water are, as it were, the residue of the distillation for obtaining the several ottos. The process of Distillation (q.v.) is very simple: the fragrant part of the plant is put into the still and covered with water, and when the water is made to boil the ottos rise along with the steam, are condensed with it in the pipe, and remain floating on the water, from which they are easily separated by decanting. In this way 100 lb. of orange, lemon, or bergamot fruit peel will yield about 10 oz. of the fragrant oil; 100 lb. of cedar-wood will give about 15 oz. of oil of cedar; 100 lb. of nutmeg will yield 60 to 70 oz. of oil of nutmeg; 100 lb. of geranium leaves will yield 2 oz. of oil.

Every fragrant substance varies in yield of essential oil. The variety of essential oils is endless; but there is a certain relationship among odours as among tints. The lemon-like odours are

the most numerous, such as verberna, lemon, bergamot, orange, citron, citronella; then the almond-like odours, such as heliotrope, vanilla, violet; then spice odours, cloves, cinnamon, cassia. The whole may be classified into twelve well-defined groups. All these ottos are very soluble in alcohol, in fat, butter, and fixed oils. They also mix with soap, snuff, starch, sugar, chalk, and other bodies, to which they impart their fragrance.

The principal consumption of the cheaper sorts of fragrant ottos is for scenting Soaps (q.v.), most of which are perfumed while in a melted state with the several ottos or mixtures of them. The best qualities of soaps, however, are scented cold by grinding or squeezing the previously dried soap between granite rollers after having been mixed with the perfumes. With perhaps the exception of Tonquin bean, the 'scents' used for snuffs and tobacco can scarcely be termed perfumes. There is a large consumption of fragrant essential oils in the manufacture of toilet powders; under the various names of rose powder, violet powder, &c.; a mixture of starch and orris, differently scented, is in general demand for drying the skin of infants after the bath. Precipitated chalk and powdered cuttle-fish bone, being perfumed with otto of roses, powdered myrrh, and camphor, become 'Dentifrice.' The ottos of peppermint, lavender, rose, and others are extensively used in flavouring sweetmeats and lozenges.

It is found that some flowers either do not yield an essential oil by distillation or yield it in quantities too small to be commercially available. The perfume from these is collected by the process called *enfleurage*. The flower-farmers of the Alpes Maritimes follow this method on a very large scale with the following flowers: rose, orange, acacia, violet, jasmine, tuberose, and jonquil. In the valley of the Var there are acres of flowers, the blossoms of which are gathered by women and children, and placed in little panniers like fishermen's baskets hung over the shoulders. They are then carried to the laboratory of flowers and weighed. In the laboratory great quantities of grease, lard, and beef-suet have been collected, melted, washed, and clarified. In each laboratory there are several thousand *châsses* or *châssis* ('sashes'), upon which the grease to be scented is spread, and upon this grease the blossoms are sprinkled or laid. The *châsse en verre* is, in fact, a frame with a glass in it as near as possible like a window-sash, only that the frame is two inches thicker, so that when one *châsse* is placed on another there is a space of four inches between every two glasses, thus allowing space for blossoms. The flower blossoms are changed every day, or every other day. The same grease, however, remains in the *châsse* so long as the particular plant being used yields blossoms. Each time the fresh flowers are put on, the grease is 'worked'—i.e. serrated with a knife—so as to offer a fresh surface of grease to absorb odour. The grease being *enfleurée* or 'enflowered' in this way for three weeks or more—in fact, so long as the plants produce blossoms, or the fat is capable of absorbing more odour—is at last scraped off the *châsse*, melted, strained, and poured into tin canisters, and is now fit for exportation. Fat or oil is perfumed with these same flowers by the process of *macération*—i.e. infusion of the flowers in oil or melted fat. For this end purified fat is melted in a *bain marie*, or warm water bath, and the fresh blossoms are infused in it for several hours. Fresh flowers being procured, the spent blossoms are strained away, and new flowers added repeatedly, so long as they can be procured. Oil does not require to be warmed, but improved results are obtained when it is slightly heated.

Jasmine and tuberose produce best perfumed grease by *enfleurage*, but rose, orange, and acacia give more satisfactory products by *macération*; while violet and jonquil grease is best obtained by the joint processes—*enfleurage* followed by *macération*. In the place of glass the space is filled with a wire-net on which is laid a *molleton*, or thick cotton fabric—moleskin, soaked with oil; on this the flowers are laid, just as with solid grease. In due time—that is, after repeated changing of the flowers—the oil becomes fragrant, and it is then pressed out of the moleskin cloth. Oil of jasmine, tuberose, &c. are prepared in this way. In order now to obtain the perfume of these flowers in the form used for scenting handkerchiefs, we have only to infuse the scented fat or oil, made by any of the above methods, in strong alcohol.

In extracting the odour from solid fat it has to

be chopped up as fine as suet is chopped, put into the spirit, and left to infuse for about a month. In the case of scented oil it has to be repeatedly agitated with the spirit. The result is that the spirit extracts all the odour, becoming itself 'perfume,' while the grease again becomes odourless; thus is procured the essence of jasmine, essence of orange-flowers, essence of violets, and others already named, rose, tuberose, acacia, and jonquil. It is right to mention that the reason for producing a pomade—as these scented fats are technically termed—of orange-flowers is that the odour of the essential oil obtained by the distillation of orange-blossoms with water has not, in the least degree, the odour of the orange-blossoms from which it is obtained. The otto in fact undergoes a chemical change, and is no longer orange so far as odour is concerned. It is called *Neroli*, and is valued at from £16 to £20 the lb. weight, the variation depending upon the crop, which is of course greatly influenced by the season. The same remarks apply, though in a less marked degree, to rose.

Some idea of the magnitude of the flower industry may be gained from the following summary showing the weight of these particular flowers grown in the south of France in 1889: orange-blossoms, 1860 tons; roses, 930; violets, 147; jasmine, 147; tuberose, 74; cassia, 30; jonquil, 15. The seat of the rose industry for the production of otto of roses is Bulgaria, more especially the cantons of Kezanlik and Karlova. Here no less than 5660 lb. were produced in 1889 at an average value of say 20s. per oz.

Perfumes of Animal Origin.—Only four of these are used in perfumery—viz. Musk (q.v.), Ambergris (q.v.), Civet (q.v.), and Castor (q.v.). The aroma of musk freely imparts odour to every body with which it is in contact. Its power to impart odour is such that polished steel will become fragrant of it if the metal be shut in a box where there is musk, contact not being necessary. In perfumery manufacture tincture of musk is mixed with other odorous bodies to give permanence to the more evanescent perfumes or bouquets, the musk acting to them almost as a mordant does to a dyestuff. The usual statement as to the length of time that musk continues to give out odour is exaggerated. If fine musk be spread in thin layers upon any surface, and fully exposed to a changing current of air, all fragrance, it is said, will be gone in from six to twelve months. The finest musk, that which indeed is only really useful in perfumery, is distinguished as Tonquin musk, the average price of which is about 90s. per oz.

Civet is exceedingly potent as an odour, and when pure, and smelled at in the bulk of an ounce or so, is utterly insupportable from its nauseousness; in this respect it exceeds musk. When, however, civet is diluted so as to afford but minute quantities to the olfactories, then its sweet perfume is generally admitted; the fragrant principle is the same as that breathed by the beautiful narcissus. Civet is extensively used duly attenuated in perfumery. Its powerful and lasting odour enables it to be used in some soaps, and especially in sachets. It is one of the perfumes of 'Spanish Leather,' or *Peau d'Espagne*; the first gloves used in England were scented with it. Several thousand ounces are annually imported, the average price of which is about 9s. per oz.

Castor is in our day said to be almost obsolete as a perfume, but this is not so; for although it cannot be largely used in any given perfume on account of the almost blackness of its tincture, still when properly diluted it is extensively employed. Its perfume, when old especially, is exceedingly pleasant, and its *fixing* power is at least equal to that of musk. About 1500 lb. are annually imported, which fetch on the market about 36s. per lb.

Of late years the progress of scientific chemistry has led to the production of numerous odoriferous substances, some identical with the active odoriferous principles of plants. Among them may be mentioned vanillin, the principle of vanilla (methyl protocatechic aldehyde); coumarin, of Tonquin bean (coumaric anhydride), and many derivatives of phenol; but the majority of this class of bodies are more used in confectionery for flavouring than in perfumery. The artificial musk of L. Bauer is a delightful perfume, and has many applications in perfumery; but it differs widely in odour from true musk.

The perfumes or bouquets of the shops are really mixtures of some or several of the primitive odours of the two above-mentioned groups. An example or two will illustrate this. 'Jockey Club Bouquet'

is thus compounded: 2 gal. extract of orris; $\frac{1}{2}$ gal. each of cassia, rose, and tuberose pomades; $\frac{1}{2}$ gal. civet; $\frac{1}{2}$ gal. musk; $1\frac{1}{2}$ gal. spirits of wine; 8 oz. bergamot otto; $1\frac{1}{2}$ oz. rose. 'White Rose': 2 pints extract rose pomade; 1 pint each cassia and jasmine; $1\frac{1}{2}$ pint spirits of wine; $\frac{1}{2}$ oz. rose otto; 1 drin. patchouli otto. It is obvious that the possible variety is infinite, since there are some sixty or more primitive odoriferous substances.

Phosphorescence. Strictly speaking, the term is applied to the phenomenon, exhibited by certain bodies, of remaining luminous in the dark for some time after being exposed to a strong light. Certain preparations, such as calcium sulphide (see LUMINOUS PAINT), indurated limestone, &c., possess this property in a very high degree. With the great majority of phosphorescent bodies, however, the duration of the phenomenon is very short, rarely more than a small fraction of a second. Becquerel, who studied this phenomenon with great care, invented a very ingenious instrument for the purpose, called a *phosphoscope*. The body to be tested is placed in a small drum, which has an opening at each end. In this drum there revolve two discs, mounted on the same axle, and pierced symmetrically with the same number of holes. They are so adjusted that when a hole in one disc is opposite to the hole in the corresponding end of the drum the second disc closes the hole at its end of the drum, and *vice versa*. Light is admitted by one of the holes in the drum so as to fall on the object, and it is examined through the other hole. It is obvious that, when the discs are made to revolve, the object is alternately exposed to light and presented to the eye. By a train of multiplying wheels, these alternations may be made to succeed each other as rapidly as the observer pleases, and thus the object is presented in the dark to his eye as soon after its exposure to light as may be desired. Almost all bodies are found to be phosphorescent; for instance, some kinds of pink rubies when exposed to sunshine in this apparatus appear to glow like live coals in the dark. When phosphorescence is continuous, bodies receiving light and giving off radiation of a lower refrangibility, we have the phenomenon observed by Brewster and Herschel in quinine and certain crystals of fluor-spar, and thence called *fluorescence*. The green colouring matter of leaves, a decoction of the bark of the horse-chestnut, and the common canary glass (coloured with oxide of uranium) are bodies which exhibit this phenomenon very well. Perhaps the most striking method of studying the phenomenon is to receive in a darkened room the solar Spectrum (q.v.) on a sheet of white paper, and to pass over the coloured spaces a brush dipped in a solution of sulphate of quinine with sulphuric acid. No change is produced on the less refrangible rays, but in the blue and indigo spaces a strange change of colour is at once apparent where the liquid has been spread. This appears more strongly in the violet, and vividly in the spaces beyond the violet, where rays fall which excite no luminous sensation in the eye. By this experiment the visible length of the spectrum may easily be doubled. By using the electric light, which is peculiarly rich in these highly-refrangible rays, a prism of quartz, which allows them to pass very freely, and various fluorescent substances, Stokes has obtained spectra six or eight times as long as those otherwise visible. The characteristic of all these rays is that they are less refrangible than those from which they are produced. The entire phenomenon is, as Stokes first showed, identical in principle with Leslie's photometer, in which light was measured when changed into heat by absorption in the coloured glass, of which one of the bulbs of his differential thermometer was formed. Ordinary phosphorus (from which the phenomenon took its name) becomes luminous in the dark by slight friction; whence the common trick of drawing self-luminous figures on doors and walls with a stick of phosphorus, or an ordinary lucifer match wetted.

PHOSPHORESCENCE IN ORGANIC BEINGS.—The emission of light by minerals after insulation and the cognate phenomena of luminosity on heating, friction, cleavage, crystallisation, &c. are of quite different nature from the production of light by organisms, the special subject to which we now turn.

Luminosity due to Putrefaction or to Disease.—The fact that many organic substances (especially fish) become luminous when decaying has long been known, and has often been erroneously aduced as the chief cause of the phosphorescence of

the sea. It is only quite recently that the discovery of luminous bacilli has rendered possible any general explanation of these facts, and even yet its wide applicability remains to be proved. They have been shown to exist in several instances which will be mentioned below, and the constant association of these low forms of life with putrefactive processes at once suggests the hypothesis that luminosity under such circumstances may be due to their presence. Perhaps they may also account for the few instances in which the human body has been recorded as phosphorescent during life.

Luminosity of Healthy Living Organisms.—(1) In the vegetable kingdom the instances of the occurrence of this property are but few, and the majority of these belong to the algae and fungi, the bacilli or bacteria above mentioned being referable to the former. Most of the fungi are Hymenomycetes (*Agaricus*, spp.): in some cases the mycelium (root-like threads) gives out the light; in others, as in *A. olearius*, not uncommon at the roots of olive-trees, it is the under surface of the mushroom-like head. The light is only seen while growth is progressing; it ceases so soon as the fungus is mature. A moss (*Schistostegia osmundacea*), some grasses, a *Euphorbia* (*E. phosphorea*), a lily (*Lilium bulbiferum*), a poppy (*Papaver orientale*), and a nasturtium (*Tropaeolum majus*) have all been recorded as luminous. The last instance is worthy of note as having been observed by the daughter of Linnaeus in 1762.

(2) In the animal world there is not one of the larger groups, up to and including the fishes, which does not afford some good examples of this phenomenon. A complete list of these would be outside the scope of such an article as the present; it must suffice to mention some of the best instances in each class, indicating briefly the nature of the photogenic mechanism. Among the Protozoa the small spheroidal *Noctiluca miliaris* is perhaps the most widely spread instance of this property, this organism, or others allied to it, abounding at certain times around the coasts of the greater part of the world. The light is emitted from the general protoplasm of the body; a pocket-lens shows some points to be brighter than others, whilst a higher magnifying power shows these to be really groups of smaller points, just as a nebula is gradually resolved into stars by increasing powers of the telescope. On the high seas *Noctiluca* seems to be replaced by species of *Pyrocystis*, one of the discoveries of the *Challenger* expedition; these may possibly, however, be stages in the life-history of very similar forms. Among the Porifera (sponges) the only recorded luminous form is the larva of a species of *Reniera*. The poverty of this class is, however, more than compensated by the wealth of the Coelenterata. The common hydroid colony *Obelia geniculata*, often growing upon the fronds of *Laminaria* (sea-tangle), is a familiar instance. Numerous Medusae (jelly-fishes) must be added to the list; and here the light is variously emitted in different species: (a) from the whole surface; (b) from the marginal corpuscles; (c) from the radial canals; (d) from the ovaries. Sometimes the same genus includes both luminous and non-luminous forms. Most Pennatulidae (sea-pens) furnish instances of the possession of this property; such are the long, reed-like *Funiculina* found in Loch Torridon (Ross-shire) and on other parts of the Scottish coast, and *Pennatula*, the subject of classic researches by Panceri, where the light emanates from eight bands or tracts of specially modified tissue situated in the wall of the stomach. Alcyonarians, Siphonophores, and Ctenophores also furnish contributions to the list; amongst these last the small ovoid jelly *Beroë* was shown by Allman not to give out its light until it had remained for some time in the dark.

A few species of Ophiuroids (brittle stars) and the deep-sea asteroid *Odinia* constitute the only known instances of luminosity among the Echinodermata, but the worms furnish a larger array. More than one case has been noticed among earthworms, the most complete description being due to Professor Giard. This worm (*Photodrilus*) is $1\frac{1}{2}$ to 2 inches long, and the luminous material is due to a series of glands opening into the oesophagus. In these forms the luminosity ceases immediately after sexual congress. Among the marine Chaetopoda the power resides in the dorsal scales (elytra) of the Polynoidae, the tentacles, dorsal tubercles, &c. of Chaetopterus, and the bunch of cephalic tentacles of Polycirrus.

Of phosphorescent mollusca the small pelagic *Phylliroë bucephala* is of importance, because the

transparency of its tissues permits of its easy study and the successful localisation of its luminosity, which is found to reside in nerve ganglia, as well as in certain small rounded cells situated at the ends of the nerve twigs. The rock-boring bivalve (*Pholas*) is one of the longest known instances of animal phosphorescence, being recorded by Pliny, who noticed that if any one chews the animal the whole interior of his mouth becomes luminous. In this form the light is emitted from five definite patches all situated within the mantle cavity—(1) an arc corresponding with the anterior margin of the mantle, (2, 3) two triangular patches near the opening of the branchial siphon, (4, 5) two long parallel bands within the same siphon. The luminous material is secreted by the epithelial cells covering these portions of the body, and has been shown to consist essentially of two substances, a white crystalline body (luciferine) and a ferment (luciferase); by the mixture of these two in a test-tube it is possible to reproduce the light at will, without the presence of living matter. The ferment is most likely produced by a certain bacillus, which occurs in large numbers in small pits in the walls of the siphon.

Interesting observations upon bacilli as the cause of phosphorescence have also been made on Crustacea of the genera *Talitrus* and *Orchestia* (sand-hoppers) in a state of disease; the malady, and the consequent luminosity, can be transferred to healthy specimens by inoculation, and the germs can be reared in artificial media in the usual manner. It would appear that the sand-hoppers infect themselves with the bacilli from dead fish on which they habitually feed. Many other Crustacea, however, are luminous under normal conditions, as, for instance, some Copepoda (*Sapphirina*), and more particularly the Schizopoda, one of which, *Nyctiphanes norvegica*, is not uncommon in the deep waters of Loch Fyne as well as on the Norwegian coast. Definite organs (photosphaeria) are here present for the production of light; one in the stalk of each eye, one at the root of each first, and one at the root of each penultimate, thoracic limb, and one under each of the first four segments of the abdomen. Each organ, as has been proved by microscopic sections, is in reality a miniature bull's-eye lantern, only equalled in complexity by the organs of certain fishes. Several phosphorescent Ascidians are known, the most conspicuous being the pelagic colony *Pyrosoma*, in which each individual zooid has two rounded luminous organs. The researches of the recent deep-sea expeditions have revealed quite a large number of phosphorescent fishes, with specialised organs of many different types. Some of these appear to be glandular, whilst others are optical instruments of great complexity, with spheroidal and parabolic reflectors to send the light in definite directions and with lenses to concentrate it. In some of the abyssal Lophioids (angler-fish) the modified dorsal fin-ray which acts as a lure has a phosphorescent extremity, no doubt to render it more attractive.

There still remain for consideration the phosphorescent insects, which belong almost exclusively to the Hemiptera (bugs) or the Coleoptera (beetles). To the former belong the lantern-flies (*Fulgora* and allied genera), though it must be mentioned that the possession of this power by these insects has been denied by more than one good observer. Luminous beetles appertain to the families Lampyridae and Elateridae. The glow-worm (*Lampyris splendidula*) and the Italian firefly (*Luciola italica*) are good examples of the former, and have been often described. In both cases the organs, which are situated in a certain number of the posterior segments of the abdomen, consist of two layers, of which the dorsal contains large quantities of uric acid salts, and the ventral clear cells, which are arranged in cylindrical lobules. In some species both sexes are luminous, in others only one. In the Mexican firefly or *Cucujos* (*Pyrophorus noctiluca*), which belongs to the Elateridae or click-beetles, the organs are three in number, one in each upper and hinder angle of the prothorax, and one much larger occupying the centre of the ventral surface of the first abdominal segment. This last is invisible while the insect is at rest, but shines forth when it spreads its wings and raises its abdomen in flight. Both the eggs and larvae of this species are luminous.

As regards the physical peculiarities of the light, it varies in colour in different cases, being blue in the mycelium growing in rotten wood, in *Cunina*, *Beroë*, *Pyrosoma*, and *Lampyris*; green in a species of *Agaric*, *Pteroeides*, in Ophiuroids, and in *Pyro-*

phorus; yellow in *Noctiluca*, *Bolina*, and with a reddish tinge in a species of *Cestum*; purple in *Funiculina* and *Fulgora*; whilst in *Pyrosoma atlanticum* and an *Appendicularia* observed by Giglioli it has been stated that the light varies in colour. In all cases in which the matter has been investigated the spectrum has been found to be continuous; the amount of heat given off in connection with the process seems to be quite infinitesimal, though actinic rays have been shown to be present. The phenomenon would appear to consist in a definite vital process, which, in these cases, leads to the production of radiant energy just as in other instances to the evolution of heat or of electricity.

The uses of this property to its possessors may, so far as is known at present, be grouped under four heads: (a) It enables the sexes to find each other, as in *Luciola* and earthworms; (b) it is possessed by so many stinging Coelenterates that in them we may fairly regard it as a warning signal, and it may have been adopted by stingless forms for the same purpose by mimicry; (c) it may serve to attract prey, as in the phosphorescent lure of the deep-sea angler-fish (*Melanocetus*, &c.); (d) it may illuminate the surrounding regions and enable the light-producing animal to find its way, as in *Pyrophorus*, *Nyctiphanes*, and many deep-sea fish. So many deep-sea animals are possessed of luminous qualities that it has been assumed that these living lights play an important part in the economy of life in those regions; this hypothesis is commonly known as the 'abyssal theory of light.' See the articles FIREFLY, GLOW-WORM, and works there cited.

Phosphorus (sym. P; atom. wt. 31; molec. wt., vapour = P_4 = 124; do. at white heat, P_2 = 62) is one of the metalloids or non-metallic elements, although, in its combining relations, it is closely connected with the metals arsenic and antimony. This substance affords an excellent example of Allotropy (q.v.); that is to say, it may be made to occur under different forms presenting different properties. Ordinary phosphorus and the red variety are the only important forms. We shall speak of them as phosphorus and red phosphorus respectively.

Phosphorus at ordinary temperatures is an almost colourless or faintly yellow solid substance of sp. gr. 1.836, having the glistening appearance and the consistence of wax, and evolving a disagreeable alliaceous odour, which, however, is probably due to the action of the oxygen of the air upon it. It fuses at 44.2° C. (111.5° F.) into a colourless fluid; and, if the air be excluded, it boils at 290° C. (554° F.), and is converted into a colourless vapour of sp. gr. 4.35 (air = 1.00). If, however, it be heated to about 60° C. (140° F.) in the air it catches fire, burns with a brilliant white flame, and is converted into phosphoric anhydride; and indeed it is so inflammable that it will catch fire at ordinary temperatures by mere friction. As the burns which it occasions are often severe and dangerous, great caution is required in handling it; and in consequence of the readiness with which it catches fire, and of its tendency to oxidise when exposed to the air at a temperature higher than 0° C. (32° F.), it is always kept in water, in which it is insoluble. It is slightly soluble in ether, but dissolves freely in benzol, in the fixed and essential oils, and in bisulphide of carbon; and, on allowing its solution in a volatile solvent to fall upon filtering paper, the finely-divided phosphorus absorbs oxygen so rapidly as spontaneously to catch fire as soon as the solvent has evaporated. Phosphorus shines in the dark from the slow combustion which it undergoes; and hence its name, from the Greek words *phōs*, 'light,' and *phoros*, 'bearing.' Its power of forming ozone is noticed in the article on that substance. Taken internally, phosphorus is a very powerful irritant poison; and it is the active ingredient of some of the preparations employed for the destruction of vermin. Its fumes give rise to a peculiar form of necrosis of the jaw and to fatty degeneration of the kidney, which used to be common amongst the makers of lucifer matches.

Red phosphorus is prepared from the ordinary variety by heating the latter in a closed iron vessel to a temperature of 240° C. (464° F.). It was discovered by Schrötter in 1845, and is a compact solid substance of a dark red colour, and with a metallic lustre. It differs much in its properties from common phosphorus, being devoid of odour, does not shine in the dark, undergoes no change

when exposed to the air even for years, and cannot be set on fire by moderate friction or percussion. Moreover, it is insoluble in all the solvents of common phosphorus, and is not poisonous. It bears heating to nearly 260°C . (500°F .) without taking fire, and has a specific gravity of 2.16. By using red instead of white phosphorus for lucifer matches there is no risk to the health of the operatives. Safety matches contain chlorate of potash and ignite on a surface containing a mixture of red phosphorus and sulphide of antimony (see MATCHES).

Phosphorus is not met with in nature in an uncombined state; but it occurs in rocks of various kinds and ages, and in some countries abundantly as apatite or phosphorite, both of which are composed of phosphate of lime. It is also found in the form of Coprolites (q.v.), or the dung of extinct animals, and more rarely as wavellite (phosphate of alumina) and vivianite (phosphate of iron). In many volcanic rocks apatite is found in minute crystals or particles, and by the decomposition of these rocks it passes into the soil. From the soil it is extracted by plants, which accumulate it (especially in the seeds of the cereals) in quantity sufficient for the wants of the animals which they supply with food. In the animal system phosphate of lime forms 57 per cent. of the bones; phosphates of the alkalies, especially of soda, occur freely in the animal fluids; and in fibrine, albumen, and nervous matter phosphorus is universally present, although we do not clearly know in what form of combination it occurs.

Phosphorus was originally discovered in 1669 by Brandt, a Hamburg chemist, who obtained it from urine. Gahn and Scheele were, however, the first to discover its presence in bone, and to employ that material for its preparation. The following are the leading steps of the method now usually employed in obtaining it on the large scale. Bones are burned to whiteness, and powdered; and this bone-ash is then mixed with sulphuric acid in such quantity as to decompose the phosphate of lime occurring in the ash, $\text{Ca}_3(\text{PO}_4)_2$, partly into insoluble sulphate of lime, partly into a soluble superphosphate of lime, whose composition is represented by the formula $\text{H}_2\text{Ca}(\text{PO}_4)_2$. The solution of the superphosphate is evaporated to a syrup, mixed with charcoal, and submitted to distillation in an earthen retort exposed to a red heat. Phosphorus rises in vapour, and is conveyed by means of a bent tube into water, in which it condenses in yellow drops. Two distinct processes take place within the retort. The first consists in the decomposition of the superphosphate of lime into bone-earth and hydrated phosphoric acid; while the second consists in the deoxidation, by means of the carbon, of the liberated phosphoric acid into phosphorus—a process accompanied by the evolution of carbonic oxide gas. After being pressed in a fused state through wash-leather, and further purified, it is forced into tubes, in which it is allowed to solidify, giving it the usual form of sticks. Sombrierite (see APATITE) is now largely substituted for bones in the manufacture of phosphorus.

Phosphorus forms two known oxides—phosphorous anhydride, P_2O_3 , obtained by the slow oxidation of phosphorus in dry air; phosphoric anhydride, P_2O_5 , obtained by the combustion of phosphorus in an excess of dry air or oxygen. The latter is a snow-like substance which has a great avidity for water, and is therefore very useful in the laboratory as a desiccating agent.

Phosphorus forms five acids—hypophosphorous acid, $\text{H}_3\text{P}_2\text{O}_4$, monobasic (the anhydride, P_2O_3 , is not known); phosphorous acid, $\text{H}_2\text{P}_2\text{O}_4$ ($= \text{P}_2\text{O}_3 + 3\text{H}_2\text{O}$), dibasic, obtained by slow oxidation of phosphorus in moist air or by passing chlorine gas through phosphorus under hot water; metaphosphoric acid, HPO_3 ($= \text{P}_2\text{O}_5 + \text{H}_2\text{O}$), monobasic, obtained by dissolving P_2O_5 in water or by heating ordinary phosphoric acid to redness; pyrophosphoric acid, $\text{H}_4\text{P}_2\text{O}_7$ ($= \text{P}_2\text{O}_5 + 2\text{H}_2\text{O}$), tetrabasic, obtained by acting upon lead pyrophosphate with sulphuretted hydrogen, the lead salt being prepared from soda pyrophosphate, which is obtained by heating such a phosphate as Na_2HPO_4 , of which two molecules give off one of water and form $\text{Na}_4\text{P}_2\text{O}_7$; phosphoric or orthophosphoric acid, H_3PO_4 , tribasic, prepared by boiling P_2O_5 in water, or from bone-ash and sulphuric acid; the last-named acid has three sets of salts, the hydrogen in the acid being more or less completely replaced—e.g. NaH_2PO_4 , Na_2HPO_4 , and Na_3PO_4 , which are obtained by more or less completely neutralising

phosphoric acid with soda.

The discovery of phosphoric acid was made in 1740 by Marggraf; the discovery of its true chemical nature is, however, due to Lavoisier, and that of its various modifications and its polybasicity to the investigations of Graham. The salts of phosphoric acid are phosphates; and they are of great value, when in a soluble form or when they can become soluble through weathering, as manures (see MANURE). Of late years mineral phosphates have been largely worked up; and a new source of phosphatic manure has become available in the alkaline slag of the Thomas-Gilchrist process, whereby the phosphorus is removed from iron by means of lime.

Phosphorus combines with hydrogen in three proportions to form phosphuretted hydrogen gas, PH_3 ; liquid phosphide of hydrogen, P_2H_4 ; and solid phosphide of hydrogen, P_4H_2 . Of these the first alone requires notice in these pages. There are various processes for obtaining the gas, one of the simplest being by boiling fragments of phosphorus in a concentrated solution of hydrated potash, in which case hypophosphite of potash is formed, while phosphuretted hydrogen gas is extricated. The reaction is explained by the equation $4\text{P} + 3\text{KHO} + 3\text{H}_2\text{O} = 3\text{KPO}_2\text{H}_2 + \text{PH}_3$. The gas thus evolved is colourless, possesses a characteristic fetid odour, and has the remarkable property of taking fire spontaneously in atmospheric air or in oxygen gas, with the production of anhydrous metaphosphoric acid and water. There is reason to believe that perfectly pure phosphuretted hydrogen gas does not possess the power of igniting spontaneously, and that the self-lighting gas always contains a minute quantity of the vapour of the liquid phosphide, P_2H_4 . The luminous phenomenon known as Ignis Fatuus (q.v.) has been referred to the natural evolution of the gas. The compounds of phosphorus with sulphur, chlorine, iodine, bromine, &c. are not of practical importance.

Phosphorus is rarely employed in medicine as a nervous stimulant, in consequence of its poisonous properties. The symptoms induced by this poison are those of acute inflammation of the stomach and bowels; the treatment is the administration of large quantities of mild demulcent fluids, and of magnesia. Dilute phosphoric acid is included in the British Pharmacopœia, but is not very much employed. It may be prescribed in much the same cases as those in which sulphuric and nitric acids are employed, and is less likely to disturb the digestive functions, if employed for a long period, than the other mineral acids. It has also been recommended, when properly diluted, as a serviceable acidulated drink for assuaging the thirst in diabetes. It may be prescribed in half-drachm doses.

Photogravure. By this process the finest possible results are obtained, but the expense of producing pictures by its aid, which is akin to the operation of copperplate printing, limits its use to high-class book-work. It is also used by Bousod, Valadon & Co., by Durand of Paris, by the Autotype Company, by Messrs Annan & Swan of Glasgow, and others for the production of large pictures which rival the finest steel engravings in their delicacy and finish. Photographs can be reproduced in this form, but the process seems to be more largely employed for obtaining engraving-like copies of celebrated pictures. The process is so perfect that every touch of the painter's brush is clearly seen in the copy, and even the upstanding ridges of paint in the bolder touches are rigidly reproduced. There are naturally different ways by which printing plates for use in this process are made, and a brief description of two methods only must here suffice to give an indication of the line of operations. (1) A gelatine relief is obtained by exposing bichromated gelatine to the action of light beneath a negative. But the gelatine employed is mingled with a certain quantity of graphite (black lead) in a more or less granular form. This addition causes the resulting relief to have a surface which is granular in character, and which is also a conducting one to electricity. If therefore the relief be placed in an electrotype bath it will speedily become covered with a deposit of copper. From the copper plate so formed copies on paper can be obtained by the usual copperplate printing process. (2) A bichromated gelatine print—negative in character—is developed upon the specially prepared surface of a copper plate, which

is then subjected to the action of a solution of perchloride of iron. This penetrates the gelatine more or less quickly according to its varying thickness, and then attacks the copper, which is eaten away by the chemical action that ensues. Thus in the end the copper plate bears on its surface an etched image, penetrating more or less in depth according to the shadows and lights of the gelatine image previously affixed to it. The plate is next 'steel'-faced and printed in the copperplate press. (It is often necessary to resort to hand-finishing in order to get the finest results.)

Photophone is the name of a comparatively simple apparatus which may be said to achieve the feat of transmitting articulate speech to a distance along a beam of light. It was first described in 1880 by Professor Graham Bell, known in connection with the telephone, at the Boston meeting of the American Association; but already in 1878 its inventor had announced the possibility of 'hearing a shadow' by means of a similar agency. The success of the photophone depends on the peculiarities of the metal selenium. Crystalline selenium offers a high degree of resistance to the passage of an electric current; it is eminently sensitive to light; and the resistance is less when exposed to light than in the dark, being in some cases only a fifteenth in the light of what it is in the dark.

Founding on these peculiarities, Professor Graham Bell, his friends, and assistants devised some fifty forms of apparatus, for so varying the transmission of light to prepared selenium as to produce audible sound. In the photophone found most serviceable the transmitter is a plane mirror of silvered microscope glass or thin mica; the receiver, fixed at a distance without any connection, is a parabolic reflecting mirror, in the focus of which is placed a sensitive selenium 'cell,' connected in local circuit with a battery and telephone. When the apparatus is used, a strong beam of light is concentrated by a lens in the plane mirror; the speaker directs his voice against the back of this mirror, which is thrown into vibrations corresponding with those of the voice. The reflected beam of light, to which corresponding vibrations are also communicated, is directed through a lens to the receiving mirror, and creates in the selenium-cell a rapidly variable current, which at the end of the telephone attached becomes audible again as vocal sound. When first described, the photophone had been used effectively with a distance of 230 yards (over a furlong) between transmitter and receiver. The rays of the oxyhydrogen light, or of an ordinary kerosene lamp, suffice for transmitting articulate speech. The loudest sounds obtained from the photophone were produced by means of a perforated disc, noiselessly revolving so as rapidly to interrupt the light in transmission.

It was also found that a very audible sound could be procured from the selenium without the aid of telephone and battery. A beam of intermittent light will produce a strong musical note from the selenium. Further experiment showed that selenium is not the only substance thus sensitive to light. Still louder sounds than these obtained from the selenium directly, though not articulate, were got from diaphragms of hard india-rubber and of antimony; and sounds of varying intensity were given out by many other substances, including gold, silver, platinum, copper, zinc, lead, paper, parchment, and wood.

Picric Acid (Trinitrophenol), $\text{C}_6\text{H}_3(\text{NO}_2)_3\text{OH}$. This substance appears in the form of pale yellow crystalline scales. It is obtained by the action of nitric acid on phenolsulphonic acid. Equal parts of phenol and concentrated sulphuric acid are mixed together, and placed in a suitable vessel, which is heated till the mixture reaches 212°F . (100°C). Nitric acid of the specific gravity 1.3 is then added. On cooling, a crystalline mass is produced which is filtered and drained. A washing with cold water follows, and then the picric acid is further purified by recrystallising it from water containing a small proportion (0.1 per cent.) of sulphuric acid. Picric acid is easily soluble in hot, but only slightly in cold water. It is also soluble in alcohol and ether. Its taste is intensely bitter, and its tinctorial power is very great, the solutions of it having a strong yellow colour (see DYEING, Vol. IV. p. 141). It has been much used for dyeing silk, wool, and leather. As it does not adhere by itself to vegetable fibre, it serves for a test to distinguish cotton from wool or silk. The presence

of cotton in a mixed fabric can therefore be detected by steeping it in a hot solution of the acid, and afterwards washing it. Then, with the aid of a microscope, the difference between the wool or silk, both of which retain the dye, and the cotton, which does not, will be made clear. Picric acid is poisonous, and its ammonia salt is used as an ingredient in explosives (see MELINITE). It was formerly called Carbazotic Acid.

Pigments used in artistic work vary much in permanence; not a few of the pictures painted by distinguished artists during the 18th and the first half of the 19th century are already more or less faded by the action of light or otherwise injured by impurities in the atmosphere of rooms. It is imprudent to expose any kind of artistic work in colours to direct sunlight or even, it would seem, to the light of electric arc lamps. The following refers to the durability of pigments employed in oil-painting, when continuously exposed to fairly strong daylight. Among blue colours, ultramarine, both real and artificial, is permanent; while Prussian blue is liable to some change, and indigo is fugitive. Among red colours, vermilion and the red ochres are perfectly durable; while the madder reds and purples can hardly be so thoroughly relied upon, and the carmine and crimson lakes, from cochineal, quickly give way. Among the yellows, raw sienna, yellow ochre, as well as the cadmium and Naples yellows, are quite stable; while Indian, chrome, and lemon yellows, and also aureolin, although less so, are yet fairly durable, but gamboge and yellow lake are not. Among greens, oxide of chromium undergoes no change, terre verte is practically permanent, and so also is emerald green, but it is blackened by contact with cadmium yellow. Among browns, burnt sienna, raw and burnt umber, cappagh brown, and Caledonian brown do not at all fade; but hardly as much can be said of madder brown, Cologne earth, and Vandyke brown, although these are fairly durable. Asphaltum or bitumen has a tendency to move on the canvas unless very carefully prepared, and its rich brown colour is not altogether permanent. Lampblack, ivory black, and charcoal black are quite durable, so also are flake white, zinc white, and baryta white. It is generally the case that a colour produced by a mixture of permanent pigments is also permanent, and it may be added here that flake white (white lead), so much used to mix with other colours for light tints, is liable to discolour when exposed to sulphuretted hydrogen (an occasional impurity in coal-gas), and this colour has also a tendency to tarnish when kept in the dark.

The above remarks on colours made up with oil apply equally to water-colour pigments, with a few exceptions. These are vermilion, especially if artificial, Naples yellow, chrome yellow, and madder brown, the permanency of which cannot be relied upon in Water-colours, under which head some further remarks on this subject will be found.

Fuller information about the pigments named above, as well as others, will be found under the heads ASPHALT, BLACK, BLUE, GREEN PIGMENTS, LAKES, OCHRES, PURPLE COLOURS, RED COLOURS, and YELLOW COLOURS. The oils and varnishes used as media for pigments, as well as the nature of the prepared canvas or paper used for painting upon, have all a bearing on the preservation of the colours of a picture.

Plasters are a class of medicinal agents consisting of 'adhesive substances, spread upon leather or cloth, so as to stick to the part of the body to which they are applied.' The plasters of the British Pharmacopœia owe their adhesiveness either to a combination of oxide of lead with fatty acids, or to the presence of a tenacious resin, or to both. The most important are lead plaster, or diachylon, which enters into the composition of many of the others; resin and pitch plasters; belladonna and opium plasters; mercury and ammoniacum and mercury plasters; and cantharides or blistering plaster. Some of the most tenaciously adhesive of plasters (not in the Pharmacopœia) are made with preparations of india-rubber. Court or sticking plaster, for dressing slight wounds, consists of a thin layer of isinglass spread upon silk, and differs from the others mentioned in requiring to be softened with warm water before it will adhere; Goldbeater's Skin (q.v.) is also used for the same purpose. They are employed with two distinct aims—viz. to act mechanically,

as by affording artificial support to weak muscular structures, by preventing threatened or tedious excoriations, by protecting parts already excoriated from the action of the air, &c.; and to act *medically* as counter-irritant, stimulant, discutient, alterative, anodyne, &c.

Poison is commonly defined to be a substance which, when administered in small quantity, is capable of acting deleteriously on the body; but this definition is obviously too restricted, for it would exclude numerous substances which are only poisonous when administered in large doses, as the salts of lead, antimony, &c.; hence the quantity required to kill must not enter into the definition. A good practical definition of a poison is 'any substance or matter which, when introduced into the body in any way, can destroy life by its own inherent qualities without acting mechanically.' This definition includes poisonous solids, liquids, and gases of definite chemical composition—the products of decomposition or of bacterial organisms, and the virus of contagious diseases. The last mentioned produce the symptoms of the various infectious and contagious diseases, and are not included in treatises on poisons. The others are classified sometimes according to their source, as mineral, vegetable, and animal; or more conveniently according to their action, as *Irritants*, *Narcotics*, and *Narcotico-irritants*.

The *Irritants*, when taken in ordinary doses, speedily occasion intense vomiting and purging and severe abdominal pain. They act chiefly on the stomach and intestines, which they irritate, inflame, and frequently corrode, and may thus occasion ulceration, perforation, or gangrene. Amongst those which possess corrosive properties are the strong mineral acids, caustic alkalies, corrosive sublimate, &c.; whilst among the pure irritants which exert no destructive chemical action on the tissues with which they come in contact may be mentioned cantharides. The *Narcotics* act specially on the brain and spinal cord. Amongst their most common symptoms are giddiness, headache, obscurity of sight or double vision, stupor, loss of power of the voluntary muscles, convulsions, and, finally, complete coma. These poisons have no acrid, burning taste, nor do they usually give rise to vomiting or diarrhoea, and, excepting a slight fullness of the cerebral vessels, they leave no well-marked post-mortem appearance. They are few in number, and none of them belong to the mineral kingdom. The *Narcotico-irritants* have, as their name implies, a mixed action. At varying periods after they have been swallowed they give rise to vomiting and purging, like irritants, and sooner or later produce stupor, coma, paralysis, and convulsions, owing to their effect on the brain and spinal marrow. As familiar examples we may

point to monkshood, tobacco, and poisonous mushrooms. Sometimes the more violent of the poisons here classed as irritants are made into a separate group—*Corrosives*; the narcotics are put under the head *Narcotics*; and the *gaseous* poisons are treated as a separate class.

Under the head of *Irritant Poisons* may be included (1) Mineral Acids, as sulphuric, nitric, and hydrochloric acids; vegetable acids, and some of their salts, as oxalic acid, binoxalate of potash, and tartaric acid (in doses of half an ounce or more); the alkalies, as pearl-ash (carbonate of potash), soap lees (carbonate of soda), ammonia and its sesquicarbonate in strong solution; and metallic compounds, as white arsenic (arsenious acid), yellow arsenic (orpiment), corrosive sublimate, pernitrate and other salts of mercury, acetate of lead (sugar of lead) in doses of an ounce and upwards, sulphate of copper (blue vitriol), subacetate of copper (verdigris), arsenite of copper (commonly known as *Scheele's green* or *emerald green*, which has been employed under the name of *extract of spinach* for colouring confectionery), tartarated antimony, chloride of antimony (butter of antimony), chloride of zinc (Sir W. Burnett's Fluid), nitrate of silver (lunar caustic), sulphate of iron (copperas or green vitriol), and bichromate of potash; (2) Vegetable Substances—viz. colocynth and gamboge in large doses, savin, croton-oil, elaterium, &c.; and (3) Animal Substances, such as cantharides, to which must be added the occasional cases in which sausages, and certain fish and molluscs, usually quite innocuous, act as irritant poisons. The *Narcotic Poisons* include opium, hydrocyanic (or prussic) acid, cyanide of potassium, henbane, alcohol, ether, chloral, and

chloroform. The *Narcotico-irritant Poisons* include nux vomica, meadow saffron (*Colchicum*), white hellebore, foxglove, common hemlock, water hemlock (*Cicuta virosa*), hemlock water-dropwort (*Oenanthe crocata*), fool's parsley, thorn-apple, monkshood or aconite, deadly nightshade, tobacco, Indian tobacco (*Lobelia inflata*), the bark and seeds of the common laburnum, the berries and leaves of the yew-tree, and certain kinds of fungi.

The cases in which there are antidotes qualified to neutralise chemically the action of the poison are few in number. For the *mineral acids* chalk or magnesia in water must be used, with the view of neutralising them, after which milk should be given freely. The *alkalies* and their *carbonates* must be neutralised by vinegar and water, or lemon-juice mixed with water, after which milk should be given. For *oxalic acid* the antidote is chalk or magnesia in water, by which an insoluble oxalate of lime or magnesia is formed. For *arsenic* the hydrated peroxide of iron has been regarded as an antidote, but its efficacy is doubtful. Vomiting should be excited by the administration of a scruple of sulphate of zinc in warm water, and, after the stomach has been well cleared out, demulcent fluids, such as flour and water or milk, should be given. *Corrosive sublimate* combines with albumen (white of egg), and forms an insoluble inert mass; *nitrate of silver* is neutralised by chloride of sodium (common salt) dissolved in water; *tartarated antimony* is to a great degree rendered inert by the administration of decoction of bark or gall-nuts; and *acetate of lead* is rendered inert by the administration of sulphate of magnesia, which converts it into an insoluble sulphate of lead. In all cases of suspected poisoning, in which the nature of the poison is not known, the safest course is at once to produce vomiting by sulphate of zinc, or in its absence by a dessert-spoonful of flour of mustard suspended in tepid water, and to continue the vomiting till all the contents of the stomach are discharged, after which milk should be given freely.

Most of the known gases have a poisonous action when inhaled into the lungs; in these cases death may be due simply to suffocation or to a specific action of the gas. *Carbonic Acid* (q.v.), although seldom employed as an instrument of murder, is a frequent cause of accidental death, and in France is a common means of self-destruction. It is established by numerous experiments that air containing more than *one-tenth* of its volume of carbonic acid will, if inhaled, destroy life in man and the higher animals; when diluted with two or more volumes of air it can be breathed, and produces symptoms of vertigo and somnolency, and so great a loss of muscular power that the individual, if in an erect or sitting position, falls as if struck to the ground. The respiration, which at first is difficult and stertorous, becomes suspended. The action of the heart is at first violent, but soon ceases, sensibility is lost, and the person now falls into a comatose or death-like state. Those who have been resuscitated usually feel pain in the head and general soreness of the body for some days, and in a few severe cases paralysis of the muscles of the face has remained. The patient must, of course, be at once removed from the poisonous atmosphere, after which artificial respiration should be had recourse to. If the skin is warm cold water may be poured on the head and spine; while if the surface be cold a warm bath should be employed. When respiration is re-established venesection will often relieve the congestion of the vessels of the brain. The inhalation of oxygen gas is said to have been of service in these cases. *Carbonic oxide* is also an active poison, and is present in coal-gas and in charcoal fumes. Both carbonic acid and carbonic oxide act as powerful narcotics. The fatal power of ordinary coal-gas as an asphyxiant and irritant is probably due to the carbonic oxide present; the post-mortem appearances are very similar in cases of poisoning by coal-gas and by carbonic oxide. *Sulphuretted hydrogen*, which occurs abundantly in foul drains, sewers, cesspools, &c., is a gaseous poison whose effects are often noticed. Nothing certain is known of the smallest proportion of this gas required to destroy human life; but air containing only $\frac{1}{100}$ th of its volume of this gas will destroy a dog; and when the gas exists in the proportion of $\frac{1}{50}$ th it will kill a horse. During the construction of the Thames Tunnel the men engaged in the work suffered severely from the presence of this gas, which was probably derived from the action of the water on the iron pyrites in the clay, and which issued in sudden

bursts from the walls. By respiring this atmosphere the strongest and most robust men were in the course of a few months reduced to an extreme state of exhaustion, and several died. The symptoms with which they were first affected were giddiness, sickness, and general debility; they became emaciated, and fell into a state of low fever accompanied by delirium. In this case the dilution was extreme; when the gas is breathed in a more concentrated form the person speedily falls, apparently lifeless. It appears to act as a narcotic poison when concentrated, but like a narcotic-irritant when much diluted with air. The action of the vapour of *sulphide of ammonium*, which is also commonly present in cesspools, &c., is probably much the same as that of sulphuretted hydrogen. Many of the gases which are only found as products of the laboratory are in the highest degree poisonous, as arseniuretted hydrogen; but as few persons run the risk of inspiring them it is unnecessary to enter into details.

In secret poisoning various preparations of arsenic seem once to have been most frequently used. In the 17th century this atrocious practice became of specially frequent occurrence; and from this time it rapidly increased, spread over western Europe like an epidemic, and became gradually a regular branch of education among those who professed a knowledge of chemistry, magic, or astrology. These persons regarded the knowledge of the mode of preparing secret poisons as of the highest importance, and many of them realised large sums by the sale of their preparations, and occasionally of the secret of their composition. It was in Italy and France that this art was chiefly practised and brought to the highest perfection; but it seems also to have prevailed in England to a considerable extent, for in 1531 the poisoning of seventeen persons, two of whom died, by the Bishop of Rochester's cook led to the passing of an act which declared the employment of secret poisons to be high-treason, and sentenced those who were found guilty of it to be boiled to death. This act was repealed in 1547.

The only undoubted instance of this crime which appears prominently in English history is the murder of Sir Thomas Overbury (q.v.) by Viscount Rochester (the favourite minion of James I.) and his wife, the divorced Countess of Essex. Prince Henry was falsely supposed to have been poisoned by his father, James I. (1612); and James's own death was similarly ascribed to nefarious practices on the part of Buckingham, nay, even of Charles I. (Milton). Undoubtedly such was the popular impression at the time, for Dr Lamb, a conjuror and quack, who was believed to have furnished Buckingham with the poisons, was seized by the angry populace in Wood Street, Cheapside, London, and beaten and stoned to death. But it was in Italy that this mode of poisoning was most prevalent. There, judging from the writings of various authors, it seems to have been looked upon as a not unjustifiable proceeding to get rid of a rival or enemy by were speedily dissolved by the sickness and death of the husband; and further inquiries resulted in the discovery of a secret society of young matrons which met at the house of an old hag, by name Hieronyma Spara, a reputed witch and fortune-poison; and from the time of the Lombard invasion down to the 17th century Italian history teems with instances which sufficiently show that poison was both the favourite weapon of the oppressor and the protection or revenge of the oppressed. The Borgias (q.v.) are generally singled out and held up to the horror and detestation of mankind; but as far as their poisonings are concerned they merely employed this method of destroying their adversaries a little more frequently than their neighbours. To show the popular feeling on this subject we may instance the case mentioned in the *Mémoires* of Henry II., fifth Duke of Guise, of a soldier who was requested to rid the Duke of Gennaro Annese, one of his opponents in Naples. Assassination was the mode proposed to the soldier, but he shrank with horror from the suggestion, stating at the same time that he was quite willing to *poison* Annese. It was shortly after the date of this story (1648) that secret poisoning became so frequent; and the Catholic clergy, despite the rules of the confessional, felt themselves bound to acquaint Pope Alexander VII. with the extent of the practice. On investigation it was found that young widows were extraordinarily abundant in Rome, and that most of the unhappy marriages

teller, who supplied those of them who wished to resent the infidelities of their husbands with a slow poison, clear, tasteless, and limpid, and of strength sufficient to destroy life in the course of a day, week, month, or number of months, as the purchaser preferred. The ladies of Rome had been long acquainted with the 'wonderful elixir' compounded by La Spara; but they kept the secret so well, and made such effectual use of their knowledge, that it was only after several years, during which a large number of unsuspected victims had perished, and even then through a cunning artifice of the police, that the whole proceedings were brought to light. La Spara and thirteen of her companions were hanged, a large number of the culprits were whipped half-naked through the streets of Rome, and some of the highest rank suffered fines and banishment. About half a century afterwards the discovery was made of a similar organisation at Naples, headed by an old woman of threescore and ten named Toffania, who manufactured a poison similar to that of La Spara, and sold it extensively in Naples under the name of *acquaetta*, and even sent it to all parts of Italy under the name of 'Manna of St Nicola of Bari,' giving it the same name as the renowned miraculous oil of St Nicola to elude discovery. This poison, now best known as the 'Acqua Tofana' or 'Acqua di Perugia,' is said by Hahnemann to have been compounded of arsenical neutral salts; while Garelli states that it was crystallised arsenic dissolved in a large quantity of water; but both agree that it produced its effect almost imperceptibly by gradually weakening the appetite and respiratory organs. After having directly or indirectly caused the death of more than 600 persons, Toffania was at length seized, tried, and strangled in 1719. From this time the mania for secret poisoning gradually died away in Italy.

Catharine de' Medici has been frequently charged with wholesale poisoning, and in 1558 four of the Scottish commissioners who had been present at Queen Mary's marriage to the Dauphin were poisoned, it was believed, at Dieppe. But it was about the middle of the 17th century that this horrible practice seems to have become most prevalent in France. Here, too, the agents were married women, and their husbands the victims; and, as in Italy, the extent to which the practice was carried was first made known by the clergy. The government, acting on the information thus obtained, seized and imprisoned in the Bastille two Italians named Exili and Glaser, who were suspected of having been the manufacturers and vendors of the poisons. Glaser died in prison; but Exili, becoming acquainted with another prisoner named St Croix, communicated to him his secret, which the latter made considerable use of after his release, compounding in particular the poison known as 'succession powder,' which subsequently became so celebrated. It was the same St Croix who played such a prominent part in the tragical history of the Marquise de Brinvilliers (q.v.). Penautier, the treasurer of the province of Languedoc, and the Cardinal de Bonzy were both pupils of St Croix, and managed, the one to pave the way for his own advancement, and the other to rid himself of his numerous creditors by the administration of poison; but the great influence of these men and the want of direct evidence barred all proceedings against them. Secret poisoning now became fashionable; the passions of jealousy, revenge, avarice, and even petty spite were all satisfied in the same way, and as a necessary consequence other offences decreased in proportion. The prisons teemed with suspected criminals, and the 'Chambre Ardente' was instituted for the special purpose of trying these offenders. In Paris this trade was chiefly in the hands of two women named Lavoisin and Lavigoreux, who combined with the ostensible occupation of midwife that of fortune-teller, and foretold to wives the decease of their husbands, to needy heirs that of their rich relatives, taking care at the same time to be instrumental in fulfilling their own predictions. Their houses were frequented by numbers of all classes, both from Paris and the provinces, among whom were the celebrated Marshal de Luxembourg (q.v.), the Duchess de Bouillon, and the Countess de Soissons; the two former of these, however, went merely from curiosity. Lavoisin and her confederate were at last discovered, tried, condemned, and burned alive in the Place de Grève, 22d February 1680; and from thirty to fifty of their accomplices were hanged in various cities of France. So common had this

atrocious practice been that Madame de Sévigné, in one of her letters, expresses a fear lest the terms 'Frenchman' and 'poisoner' should become synonymous. For two years after the execution of the two Parisian poisoners the crime continued to be largely committed, being fostered by the impunity with which offenders of high rank were allowed to escape; and it was not till more than a hundred persons had died at the stake or on the gallows that the government succeeded in suppressing it. The mania for secret poisoning has not since been revived to the same extent, though isolated instances of its practice have occasionally been discovered, particularly in Hungary, where, within the last half of the 19th century, very extraordinary disclosures have at different times been made of the prevalence of this frightful crime among the peasant women. During the times of slavery the Obeah men among the negroes in the West Indies were credited with being expert poisoners. They used vegetable poisons obtained from plants, and there can be no doubt were often instrumental in getting rid of tyrannical or otherwise objectionable masters.

Poppy (*Papaver*), a genus of plants of the natural order Papaveraceæ, having a calyx of two (or rarely three) sepals, which very soon fall off; a corolla of four (rarely six) petals; numerous stamens seated on a receptacle; the stigma crowning the ovary, without a style, and in the form of 4 to 20 rays; the capsule opening by pores under the persistent stigma, imperfectly divided into cells by partitions as numerous as the rays of the stigma, but which do not reach the centre, and the seeds extremely numerous. There are numerous species of poppy, mostly natives of Europe and Asia, some of them found even in very northern regions, but most of them in the warmer temperate parts. They are herbaceous plants, annual, biennial, or perennial, mostly sprinkled with bristly hairs. They have a white milky juice; a disagreeable narcotic smell, particularly when bruised; pinnatifid or bipinnatifid leaves, more rarely jagged or toothed leaves; and large showy flowers, which readily



Opium Poppy (*Papaver somniferum*):
a, whole plant; b, flower and leaf; c, ripe capsule; d, seed and section of do, enlarged. (Bentley and Trimen.)

become double by cultivation. The capsules are curious from the manner in which they fling out their seeds when the plant is shaken by the wind; each capsule being somewhat like a round or oval pepper-box, with holes, however, not in the top, where rain might get in by them, but under the projecting rim. By far the most important species is that known as the Opium Poppy (*P. somniferum*), also called the White Poppy and the Oil Poppy (see OPIUM). But the same species is important on account of the bland fixed oil of the seeds, and is much cultivated as an oil-plant. Poppy-oil is as sweet as olive-oil, and is used for similar purposes. It is imported into Britain in considerable quantities from India. The poppy is also extensively cultivated for it in France, Belgium, and Germany. The use and manufacture of this oil were for a long

time, during the 18th century, strictly prohibited in France, from a mistaken notion that it must partake of the narcotic properties of the milky juice of the plant. The seed, however, contains no opium or any narcotic principle, and was well known to the ancients as a pleasant article of food, fit to be eaten by itself or with bread; some German cakes have poppy-seed plentifully sprinkled on the top. The oil expressed from it is perfectly wholesome, and is much used in France and elsewhere as an article of food. It is believed that one-half of the oil used for cooking and otherwise for alimentary purposes in France is of this kind. The seeds yield about 40 per cent. of oil, and the oil-cake is useful for manure or for feeding cattle. The oil is sometimes used by painters and by soap-boilers; but it is not good for burning. In the cultivation of the poppy for oil the seed is often sown in autumn, where the severity of winter-frosts is not to be feared; in more northern parts it is sown in spring, and sometimes the seed is scattered on the top of the snow with which the ground is covered. Being very small it needs little or no harrowing. Early sowing is favourable to the size of the plant and the abundance of produce. Hoeing and thinning are advantageous. An open but rich soil is best for the poppy; and a sheltered situation is necessary, as in exposed situations much of the seed is scattered by the wind. The poppy does not exhaust the land so much as colza, rape, and some other oil-plants. Harvesting ought to begin when one-fourth of the capsules of each plant are open. It is accomplished by pulling the plants in such a manner as not to shake the seed out of the capsules, and tying them in sheafs, which are placed together in an erect or slightly sloping position, till the ripening of the capsules is completed, when the seed is taken out by shaking the capsules into a tub or on a cloth, great care being used to prevent any earth from the roots from getting mixed with them. Some farmers in Flanders sow poppies in alternate rows with carrots. The variety of poppy chiefly cultivated as an oil-plant has flowers of a dull reddish colour, large oblong capsules, and brownish seeds; but the white-flowered variety, with globular capsules and white seeds, is also used. The Oriental Poppy (*P. orientale*), a native of Armenia and the Caucasus, a perennial species, is often planted in gardens on account of its very large, fiery-red flowers. Its unripe capsules have an acrid, almost burning taste, but are eaten by the Turks, and opium is extracted from them. Several species are British, all of them local, rare in some places, and troublesome weeds in cornfields in other places apparently quite similar in climate. Among them is the Corn Poppy or Common Red Poppy (*P. rhoeas*), with bright-red flowers, and deeply pinnatifid leaves. The petals are mucilaginous and slightly bitter; they have a slight narcotic smell; and a syrup made of them is sometimes used as an anodyne in catarrhs and children's complaints; but they are more valued for the rich red colour which they yield. A variety with double flowers is cultivated in flower-gardens, under the name of *Carnation Poppy*. Among the ancients the poppy was sacred to Ceres.

Posset, a dietetic preparation, made by curdling milk with some acidulous liquor, such as wine, ale, or vinegar. White wine or sherry is usually preferred, but sometimes old ale is used. The milk is boiled, and whilst it is still on the fire the acidulous matter is added; if sherry, about a wine-glassful and a half to the pint of new milk is the proportion, or twice the quantity if ale. A teaspoonful of vinegar or of lemon-juice is sometimes used instead; one or two tablespoonfuls of treacle may be added, to sweeten. Taken at bedtime, it is used for colds and coughs.

Potash. See POTASSIUM.

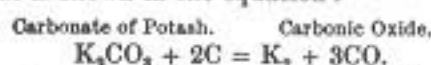
Potash Water. See AERATED WATERS.

Potassium (sym. K, equiv. 39) is one of the alkaline metals. The letter K is selected as its symbol, as being the first letter of *Kali*, the Arabic word for potash, the letter P being already taken as the symbol for phosphorus. The following are the chief characters of this metal. It is of a bluish-white colour, and presents a strong metallic lustre. It melts at 146.5° (62.5° C.), and at a red heat is converted into vapour. Its affinity for oxygen is so great that on exposure to moist air it immediately becomes covered with a film of oxide, and

hence it must be kept below the surface of naphtha. When heated it burns with a violet flame. Its intense affinity for oxygen is well shown by throwing it into water, on which, from its low specific gravity, 865, it floats. The metal abstracts oxygen from the water, and forms oxide of potassium (potash); while the liberated hydrogen carries off a small portion of the volatilised potassium, and, taking fire from the heat evolved by the energetic chemical action, burns with a brilliant violet flame. The experiment is a very beautiful one, the burning metal swimming about rapidly on the water, and finally disappearing with an explosion of steam, when the globule of melted potash becomes sufficiently cool to come in contact with the water.

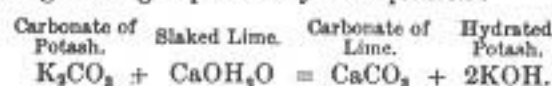
Potassium does not occur in the native state, and can only be obtained by the reduction of its oxide, potash. In 1807 Davy prepared it by decomposing its hydrated oxide (potash) by means of a voltaic current, but this process is not applicable on the large scale. It is now usually manufactured by distilling a mixture of carbonate of potash and charcoal in an iron retort.

If proper proportions are taken, the mixture is wholly converted into carbonic oxide and potassium, as is shown in the equation:



Potassium forms two compounds with oxygen, viz. a protoxide, K_2O , which constitutes potash, and is strongly basic, and a peroxide, K_2O_2 . Of these the former is the only important one.

Potash can be procured in the anhydrous form by heating thin slices of the metal in air perfectly free from moisture or carbonic acid. It is white, very deliquescent, and caustic. When moistened with water it becomes incandescent, and the water cannot be expelled by any degree of heat. A far more important substance is the *Hydrate of Potash* or *Caustic Potash* ($\text{KOH} = \text{K}_2\text{O}, \text{H}_2\text{O}$). This is commonly prepared by dissolving carbonate of potash in ten times its weight of water, and gradually adding to the boiling solution a quantity of slaked lime, equal in weight to half the carbonate of potash used. The resulting compounds are carbonate of lime, which falls as a precipitate, and hydrate of potash, which remains in solution; the changes being expressed by the equation:



The clear supernatant fluid is removed by decantation, or by means of a siphon, into a clean silver or iron basin, and is rapidly evaporated till it flows tranquilly like oil; it is then either cast into cylinders in metallic moulds, or is poured upon a cold slab, and solidifies on cooling. As so obtained it is very impure, but by solution in alcohol and evaporation a very pure article is produced.

Hydrated potash, on solidifying after fusion, occurs as a hard, grayish-white, opaque body, with a crystalline fracture, which may be readily again fused into a colourless oily fluid, but which only volatilises at a very high temperature. It is soluble in about half its weight either of water or of alcohol, and rapidly absorbs both carbonic acid and moisture from the atmosphere. It acts as a powerful caustic, and quickly destroys both animal and vegetable tissues, and hence its solutions can only be filtered through asbestos or pounded glass or sand. Its affinities are so powerful that few vessels are capable of resisting its influence. Its solution must be preserved in glass bottles into the composition of which no oxide of lead enters, as it has the property of dissolving this oxide out of the glass. Vessels containing silica (porcelain, earthenware, &c.) are decomposed, and platinum itself is oxidised when heated in contact with it.

The salts which potash forms with acids are for the most part readily soluble in water, and colourless, unless (as, for example, in permanganate of potash) the acid is coloured. Most of them are crystallisable, and they all communicate a violet tint, characteristic of potash, to the flame of spirit of wine and to that of the blowpipe. Many of them occur in animals and vegetables, and the ashes of plants contain them in large quantity.

Carbonate of Potash, K_2CO_3 , is obtained by burning plants in dry pits, dissolving the ashes in water, evaporating till the sulphates, chlorides, &c. separate in crystals, and then boiling the mother

liquid to dryness in iron pots. The quantity of pure carbonate of potash contained in it is liable to great variation, and for pharmaceutical purposes it must be dissolved in water and crystallised, the crystals containing about 20 per cent. of water. Carbonate of potash is extremely deliquescent, and is soluble in less than its own weight of water, but is insoluble in alcohol. It has an acrid, alkaline taste, and its reaction upon test-paper is strongly alkaline. It is a compound of great importance, both as a chemical reagent and as entering largely into the preparation of most of the other compounds of potash, and into the manufacture of soap and glass. The commercial carbonate is often called *Pearl Ashes*. **Bicarbonate of Potash**, KHCO_3 , is obtained in white rhombic prisms, by passing a current of carbonic acid gas through a strong solution of carbonate of potash. These crystals are permanent in the air, but are decomposed by heat; water and carbonic acid being evolved, and the simple carbonate left. This salt is much less soluble than the carbonate, requiring four parts of cold water for its solution, which is nearly neutral to test-paper, and has a much milder taste than the preceding salt. It is employed as an antacid in medicine. The **Sulphate**, K_2SO_4 , and **Bisulphate**, KHSO_4 , may be prepared by treating potash with sulphuric acid. **Nitrate of Potash** has been already described under the head NITRE. **Chlorate of Potash**, KClO_3 , occurs in white rhomboidal tablets of a pearly lustre. It has a cooling taste like that of nitre. It fuses at a gentle heat without decomposition, but on increasing the heat it gradually gives off all its oxygen, and is converted into chloride of potassium, according to the equation:



It is not very soluble, as it requires for solution 16 parts of cold and 1.7 parts of boiling water. It even surpasses nitrate of potash as an oxidising agent; and if combustible substances, such as carbon, sulphur, or phosphorus, be heated or forcibly rubbed with it, a detonation or explosion occurs. This salt is employed in the manufacture of Matches (q.v.), in certain operations in calico-printing, and for filling the friction-tubes employed for firing cannon: the best mixture for these tubes consisting of 2 parts of this salt, 2 of sulphide of antimony, and 1 of powdered glass. A mixture known as *White Gunpowder*, consisting of chlorate of potash, dried ferrocyanide of potassium, and sugar, has been employed for blasting purposes, but its preparation is accompanied by so much danger that it is seldom used. This salt does not occur as a natural product, but may be obtained along with chloride of potassium by passing a current of chlorine gas through a hot solution of caustic potash. The two salts are easily separated by crystallisation, as the chlorate is comparatively insoluble, and the chloride extremely soluble. **Hypochlorite of Potash** can only be obtained in solution. Under the title of *Eau de Javelle*, it is sold as a bleaching agent. It is obtained by passing chlorine gas through a cold dilute solution of carbonate of potash, when chloride of potassium and hypochlorite of potash are formed, from which the chloride may be removed by crystallisation. The **Phosphates of Potash**, formed by the different varieties of phosphoric acid, are sufficiently noticed in the articles PHOSPHORUS and MANURE. The **Silicates of Potash** are important compounds in connection with the manufacture of glass; they also enter into the composition of Fuchs's *Soluble Glass* (see GLASS), or *Water-glass*, and have been employed as a coating by which the decay of magnesian and other limestones may be prevented. The **Chromate and Bichromate of Potash** are noticed in the articles CHROMIUM and CALICO-PRINTING. The haloid salts of potassium may be passed over very briefly. The **Chloride of Potassium**, KCl , is obtained in large quantity in the preparation of chlorate of potash, or may be procured by burning potassium in chlorine gas, when the result of the brilliant combustion which takes place is this salt. In its general characters it closely resembles common salt, NaCl , except that the former communicates a violet and the latter a yellow tint to the flame of alcohol. It is a constituent of sea-water, of salt marshes, and of many animal and vegetable fluids and tissues. The **Bromide and Iodide of Potassium** are noticed in the articles BROMINE and IODINE. **Fluoride of Potassium**, KFl , possesses the property of corroding glass. There are several sulphides,

the most important being the *Liver of Sulphur*, prepared by fusing together carbonate of potash and sulphur. Besides its use in skin diseases, it is much employed by florists to prevent mildew on roses. The *Yellow* and the *Red Prussiate* (or the *Ferrocyanide* and *Ferricyanide*) of Potash are noticed in the article FERRIDCYANOGEN. The *Cyanide of Potassium*, KCy , may be procured by heating potassium in cyanogen gas, when brilliant combustion occurs, and the resulting product is this salt. It may, however, be more cheaply and easily prepared by fusing together 8 parts of ferrocyanide and 3 of carbonate of potassium. This salt forms colourless deliquescent crystals very soluble in water. It exhales an odour of hydrocyanic acid, and is nearly as poisonous as that acid. Its great deoxidising power at a high temperature renders it a valuable agent in many of the finer operations of metallurgy.

The following are the ordinary tests for the potassium compounds: (1) Solution of tartaric acid added in excess to a moderately strong solution of a potassium salt gives after some time a white crystalline precipitate of cream of tartar (see TARTARIC ACID). The result is hastened by stirring or shaking. (2) Solution of bichloride of platinum gives a crystalline yellow precipitate, which is a double salt of bichloride of platinum and chloride of potassium. If not previously acid, the mixture to be tested should be acidulated with hydrochloric acid. (3) The violet tint occurring in the presence of potassium in the outer flame of the blowpipe, or in the flame of spirit, has been already noticed. (4) The spectrum of a flame containing potassium exhibits a characteristic bright line at the extreme limit of the red, and another one at the opposite violet limit of the Spectrum (q.v.).

In medicine the following compounds are used: *Caustic Potash*, or *Hydrate of Potash*, KOH , which occurs in hard white pencils. From its power of dissolving the animal tissues, it is sometimes used as a caustic, although its great deliquescence renders it somewhat difficult to localise its action to the desired spot. In bites of venomous serpents, mad dogs, &c. it may be applied with advantage, and it is useful in destroying warts and fungoid growths of various kinds. *Solution of Potash*, commonly known as *Liquor potassæ*, is obtained by the process already given for the preparation of hydrate of potash. *Liquor potassæ*, in combination with a tonic infusion, is of service in cases of dyspepsia which are accompanied with excessive acidity of the stomach, such, for example, as often occur in habitual spirit-drinkers. It is also frequently given with the view of rendering the urine alkaline, or of diminishing its acidity in cases in which that secretion is too acid. The usual dose is ten drops, gradually increased to as much as a fluid drachm. *Acetate of Potash*, $KC_2H_3O_2$, is obtained by the action of acetic acid on carbonate of potash, and occurs in white foliaceous satiny masses. In its passage through the system it is converted into carbonate, and thus renders the urine alkaline. In small doses, as from a scruple to a drachm, it acts as a diuretic, and is of service in some forms of dropsy. Combined with other potash-salts, it is much given in acute rheumatism. The two carbonates and the sulphurated potash have been already referred to.

The *Chlorate of Potash* has come much into use as a popular remedy for sore throats. For this purpose it is usually employed in the form of compressed pellets, which are allowed to dissolve slowly in the mouth.

Psoriasis (from the Greek word *psora*, which signifies a cutaneous eruption, supposed by some to be the itch) is now employed to signify a disease characterised by slight elevations of the surface of the skin covered with whitish scales. The eruption begins in small rounded spots, which may remain small, or may enlarge indefinitely, the centre becoming more normal while the inflamed margin continues to extend. The spots are covered by white silvery scales, not easily detached from the skin, which, however, when they are removed, is seen to be red and dry. The parts most often affected are the fronts of the knees and backs of the elbows; whatever other parts may be attacked, these are rarely free from the eruption, and the distribution is always nearly the same on the two sides of the body. Itching is often absent altogether, and very seldom severe. The disease may occur at any age, but usually first manifests itself in youth, rarely before the age of six. It is

extremely apt to recur: it is rare for a person to suffer from it only once.

Numerous causes have been assigned for the disease; it has been attributed to scrofula, gout, and many other constitutional states; and doubtless it may be associated with them. But, with the exception of heredity, no cause has been satisfactorily shown to lead to its development. It frequently occurs in persons otherwise in perfect health, and, except in very severe cases, does not interfere in any way with their employments.

If left to itself, the disease generally tends to persist indefinitely. But in the great majority of cases it is very amenable to treatment, both local and constitutional. Locally, ointments containing tar, resorcin, pyrogallie acid, &c. are most in use; internally, arsenic is far the most valuable remedy. Where it has failed, iodide of potassium in large doses, liquor potassæ, and carbolic acid have sometimes succeeded. But some cases resist the most varied and persevering efforts for their cure; and nothing has yet been discovered which will prevent the tendency to recurrence of the disease.

Pulley, one of the mechanical powers, consists of a wheel, with a groove cut all round its circumference, and movable on an axis; the wheel, which is commonly called a *sheave*, is often placed inside a hollow oblong mass of wood called a *block*, and by the sides of this block the extremities of the axle of the sheave are supported; the cord which passes over the circumference of the sheave is called the *tackle*. Pulleys may be used either singly or in combination; in the former case they are either *fixed* or

movable. The *fixed pulley* (fig. 1) gives no mechanical advantage; it merely changes the direction in which a force would naturally be applied to one more convenient: thus, W can be raised without lifting it directly by merely pulling P down. The *single movable pulley*, with parallel cords, gives a mechanical advantage = 2 (fig. 2); for a little consideration will show that, as the weight, W , is supported by two strings, the stress on each string is $\frac{1}{2}W$, and the stress on the one being supported by the hook, A , the power, P , requires merely to support the stress on the other string, which passes round C . The fixed pulley, C , is only of service in changing the naturally upward direction of the power into a downward one. If the strings in the single movable pulley are not parallel there is a diminution of mechanical advantage—i.e. P must be more than half of W to produce an exact counterpoise; if the angle made by the strings AB and BC is 120° , P must be equal to W ; and if the angle be greater than this there is a mechanical disadvantage, or P must be greater than W . The following are examples of different combinations of pulleys, generally known as the first, second, and third systems of pulleys. In the first system one end of each cord is fastened to a fixed support above; each cord descends, passes round a pulley (to the lowest of which the weight, W , is fastened), and is fastened to the block of the next pulley, with the exception of

the last cord, which passes round a fixed pulley above, and is attached to the counterpoise, P . The tension of a string being the same in all its parts, the tension of every part of the string marked (1) in fig. 3 is that which is produced by the weight of P ; consequently, as the last movable pulley is supported on both sides by a string having a tension, P , the tension applied in its support is $2P$. The tension of the string marked (2) is therefore $2P$, and the second movable pulley is supported by a force equal to $4P$. It may similarly be shown that the force applied by the strings marked (4) in support of the last pulley (which is attached to W) is $8P$. Hence we see that, according to this arrangement, 1 lb. can support 4 lb. if two movable pulleys are used; 8 lb. if there are three movable pulleys; 16 lb. if there are four movable pulleys; and if there are n movable pulleys 1 lb. can support 2^n lb. It must be noticed, however, that in practice the weight of

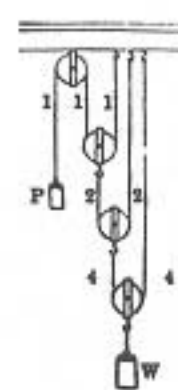


Fig. 3.

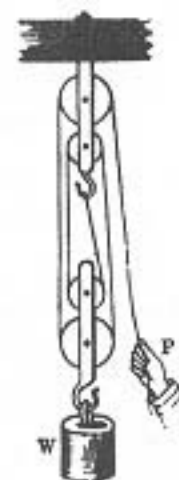


Fig. 4.



Fig. 5.

the cords, and of the pulleys, and the friction of the cord on the pulleys must be allowed for; and the fact that in this system all of these resist the action of the power, P , and that to a large extent, has rendered it of little use in practice.—The second system is much inferior in producing a mechanical advantage, but it is found to be much more convenient in practice, and is modified according to the purpose for which it is to be used; two prevalent forms are given in figs. 4 and 5. In this system one string passes round all the

pulleys, and, as the tension in every part of it is that produced by the weight of P , the whole force applied to elevate the lower block with its attached weight, W , is the weight P multiplied by the number of strings attached to the lower block; in fig. 4 $W = 4P$, and in fig. 5 $W = 6P$, the pulleys in the upper block being only of use in changing the direction of the pulling force. This system is the one in common use in architecture, in dock-yards, and on board ship, and various modifications of it—such as White's pulley, Smeaton's pulley, &c.—have been introduced; but the simpler forms shown above have been found to answer best.—The third system (fig. 6) is merely the first system inverted, and it is a little more powerful, besides having the

weight of the pulleys to support the power, instead of acting in opposition to it, as in the former case.—The mechanical advantage can be traced out by finding from the form of the combination the ratio between the run of the tackle over the last sheave and the vertical ascent of W , when motion is set up. Theoretically, the larger the number of movable pulleys in any one combination the greater is the mechanical advantage afforded by it; but the enormous friction produced, and the want of perfect flexibility in the ropes, prevent any great increase in the number of pulleys.

Pumps, machines for lifting liquids to a higher level, include (1) the Lift or Suction Pump, (2) the Lift and Force Pump, (3) the Pulsometer, (4) the Chain-pump, (5) Spiral Pumps, (6) the Centrifugal Pump, (7) the Jet-pump, (8) the Persian Wheel, (9) Scoop-wheels.

(1) *The Lift or Suction Pump* (fig. 1).— A is the cylinder (the 'barrel'), closed or open at the top; B is a pipe (the 'suction-pipe') communicating with the water to be raised; C is a 'discharge-pipe,' which may be reduced to a mere spout; D is a valve, opening upwards only; E is another valve, also opening upwards only, and borne by F ; F is the 'bucket,' a hollow cylindrical piece of wood or metal which is made, by leather or by hemp or other packing, to fit the barrel just so closely that water cannot travel between the bucket and the barrel; G is the

piston-rod, driven by hand, steam, windmill, or animal power, and moving the bucket up and down in the barrel. Each upward stroke of the piston at first lifts air, of which none can travel back past the bucket; a partial vacuum is produced in B; water ascends in B until the external atmospheric pressure is balanced by the partial atmospheric pressure below D plus the weight of the water column in B; as F now descends, air gets to the upper side of the valve, and is lifted on the upstroke, and so on: so that, if the valve D be not more than at most 33 feet above the water below (in practice 25 feet or less), water will be, step by step, pushed up B by the external atmospheric pressure until the valve D is under water; thereafter the succeeding strokes of the pump operate on the water above D and force it into the discharge-pipe, C, the external atmospheric pressure keeping the space below D filled with water. The power expended is applied (1) in lifting water; (2) in overcoming the pump-friction; (3) in overcoming the water-friction; and, (4) where the pump is ill-shaped, in producing eddies and broken water. A lift-pump must be very carefully proportioned and constructed in order to utilise, in water-lifting, one-half of the whole power expended in working it. Such pumps must work slowly, so that the valves may close properly; and an air-vessel is, if C be not a mere spout, required on C so as to minimise shock and render the outflow less intermittent, by the compression and elastic expansion of the air contained in it. The outflow is also regulated by driving two or three pumps off the same shaft and properly timing their relative motions.

(2) *The Lift and Force Pump* (fig. 2).—The piston is solid, and the valve E, instead of being carried by the piston, is fitted in the discharge-pipe. During the downward motion of the piston water is forced past the valve E; it cannot return;

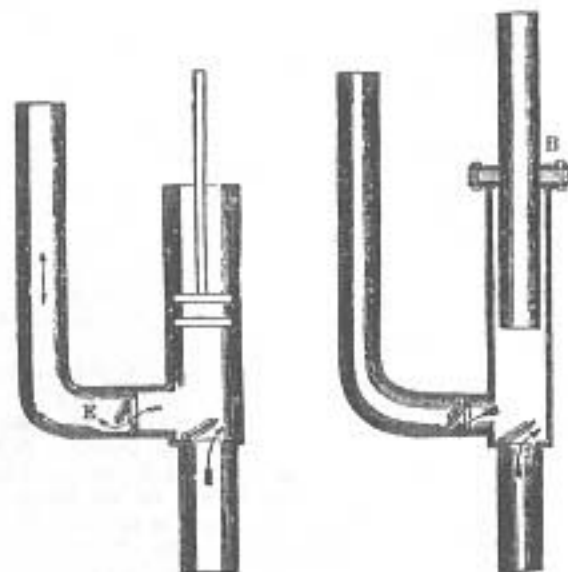


Fig. 2.

Fig. 3.

and water may thus be forced to considerable heights. Sometimes (fig. 3) the piston is made to fit, not the barrel, but the stuffing-box, B, which can be tightened down on it so as to make the fit good. An air-vessel, or a loaded hydraulic press called an 'accumulator,' is fitted on the discharge-pipe so as to minimise shock and intermittence; and double pumps are very generally employed,

either directly driven by steam-engine pistons or driven by a flywheel. Force-pumps are used for deep wells and mines, hydraulic presses, boiler feeds, creosoting timber, hydraulic lifts, steam fire-engines both land and marine, and hydraulic power supply.

(3) *The Pulsometer*.—Two chambers, A and B, converge above and communicate with a single steam-pipe; a ball-valve shuts off either A or B, but not both at the same time, from the steam; A and B each have a discharge outlet and a suction inlet, both these having valves. The whole is filled with water; the steam drives water from, say, A into the discharge-pipe: condensation takes place and the ball-valve is pulled over, so as to shut off the steam from A: the steam then acts in B in the same way as it had done in A, while in the meantime A, where there is a partial vacuum, is being filled with water from the suction-pipe. The two chambers thus act alternately. The whole contrivance can be hung by chains and let down to the required position; and it is greatly in use in contractors' work.

(4) *The Chain-pump*.—This pump is formed of plates called lifts or buckets, fastened, now generally by their centres, to an endless chain and moving upwards, in a case or 'barrel' which is in places constricted so as just to let the buckets pass. Chain-pumps are noisy and somewhat apt to break down; but they can lift very gritty or muddy material. Dredging-machines (q.v.) with their buckets are a variety of this device.

(5) *Spiral Pumps*.—An Archimedes' Screw (q.v.) is rotated round its axis so as to make water slip up the inclined plane of the screw. They are very economical in power, and they work so regularly that they act as meters.

(6) *Centrifugal Pumps* (figs. 4 and 5).—The water enters by the supply-pipes, A, A, which lead to the central orifices of the fan, B, B; it then traverses the passages, C, C, formed by the vanes and the side covering-plates, D, of the fan. The fan is made to rotate from the shaft, E. The water acquires a rotatory motion while passing through the passages of the rotating fan; it then enters the whirlpool-chamber, F, and is discharged by the pipe, G, at the circumference of F; and the velocity of

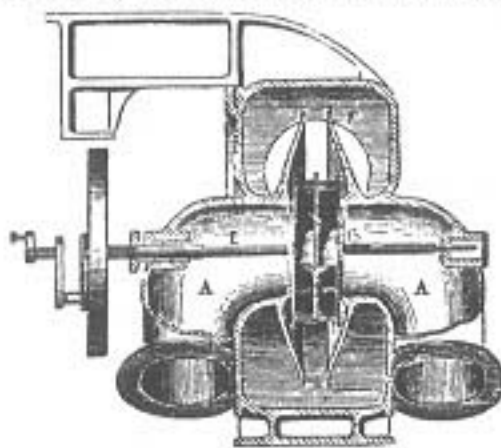


Fig. 4.

rotation of the fan determines the height to which the water will rise in the discharge-pipe. This velocity cannot conveniently be made to exceed a certain limit; hence the utility of centrifugal pumps is practically limited to low lifts; but as they can be made very large they can deal with enormous quantities of water; and they are much used for pumping in docks, canals, marsh and polder draining, land-reclaiming, and the like. As they have no valves they are little liable to become choked. In nearly all modern centrifugal pumps the whirlpool-chamber, F, the purpose of which was to reduce the ultimate velocity of outflow and correspondingly to increase the

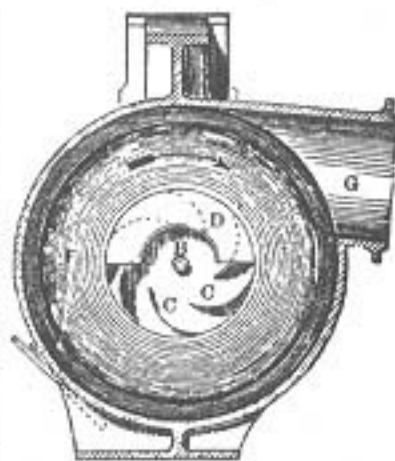


Fig. 5.

pressure, is dispensed with; and the same end is attained without wasting energy through friction in the vortex, F, by shaping the vanes of the fan so as to reduce the velocity. See Cotterill's *Applied Mechanics*.

(7) *The Jet-pump*, now not much used, is practically a Giffard's Injector (q.v.) worked by water from a height instead of by steam.

(8) *The Persian Wheel*.—An under-shot wheel (mill-wheel in which the water flows under the wheel) in which little buckets are carried by the rim of the wheel so as to pick up water from the stream and deliver it at the top of the wheel.

(9) *Scoop-wheels* or *flash wheels*: equivalent to breast water-wheels with reversed action; driven by windmills or by steam, they raise water in their buckets and deliver it a few feet higher up; in some cases they have curved blades, and the water is delivered at the centre of the wheel.

Purple Colours. Painters in oil and water colours produce various shades of purple by mixing certain red and blue pigments. For work in oil French ultramarine, often called French blue, is mixed with vermilion or some madder red (madder carmine is best), or one of these reds with cobalt blue if a pale purple is wanted. For permanent purples in water-colours the same blues are used; but one of the madder reds, not vermilion, should be mixed with them. A much richer purple than any of the above mixtures will give is produced by Prussian blue and one of the lakes from cochineal—viz. carmine or crimson lake—but it is not permanent. This purple, as well as that obtained by mixing Indian red with indigo, also fugitive, was much used by water-colour painters in past years. Purple madder is the only simple purple pigment available for the artist which is durable, and it is unfortunately costly. All purples are changed to neutral and gray tints by the addition of any yellow pigment. For house-painting moroon lake with a little French blue gives a useful purple; but some of the above mixtures also are occasionally used.

There are several ways of dyeing textile fabrics of a purple colour. The most famous of all ancient dyes was the Tyrian purple, which is said to have been discovered at Tyre many centuries before the Christian era. Among the Romans this colour was exclusively employed for dyeing the imperial robe. It was obtained from shellfish belonging to the genera *Murex*, *Purpura*, and *Buccinum*; at least it has been supposed that it was prepared from one or more species of each of these. The colour was so costly that in the time of Augustus one pound of it sold for what would amount to £36 sterling. About the year 1851 what is believed to be the same or a closely similar purple was obtained from uric acid by a peculiar treatment (see *MUREX*; *DYEING*, Vol. IV. p. 139; and *PHENICIA*). Archil (q.v.) seems to have been the only simple purple dye known in the middle ages. Purple of Cassius is a compound of gold and tin used in colouring Glass (q.v.), and in porcelain and enamel painting. It was discovered at Leyden by Andrew Cassius about 1683. A preparation of this colour was formerly used for painting miniatures in water-colour; but for this purpose purple madder, being cheaper, has taken its place.

Putty, a composition of *whiting* and *drying oil* worked into a thick paste, used by painters and glaziers, which in time becomes very hard.

Putty-powder is the binoxide or dioxide of tin, SnO_2 . It is prepared from the scum or crude oxide which forms on the surface of melted tin, which is removed and purified by calcination, and then ground to powder. Putty-powder is used for polishing stone, glass, and other substances; also for making white enamel and for giving to glass an opaque white colour.

Pyroligneous Acid, or **WOOD VINEGAR**, a crude commercial form of Acetic Acid (q.v.). It is made by the destructive distillation of wood, and, besides acetic acid, contains tar, creosote, wood-naphtha, and other products, which have to be removed if it is required in a very pure state. The best woods for the distiller are 'hard' woods, although all will yield it. Oak branches stripped of their bark are cut into short billets, which are placed in cast-iron retorts, and a sufficient heat applied to drive off the volatile constituents and carbonise the wood. This acid is of great use in the arts, especially in making the acetates used

by dyes and calico-printers; and it is also, when very carefully purified and properly diluted with water, used extensively as a substitute for common vinegar in pickling, and even for table use. It is also used in the preservation of fish, giving them a 'smoked' flavour.

Pyrophorus (from the Gr. *pyr*, 'fire,' and *phero*, 'I bear') is a term applied to any substances which take fire from the rapidity with which they are oxidised. If iron, cobalt, or nickel be reduced by hydrogen from its oxide at a low red heat, it is obtained in a state of such extreme division as to become incandescent by the oxidising action of the atmosphere; and the tendency to rapid oxidation is much increased by the interposition of some infusible matter, as a little alumina or magnesia, between the particles of the oxide. This is probably due to the cohesion of the minute particles of the reduced metal being thus mechanically prevented, and the access of air to the surface of each particle being thus facilitated. If tartrate of lead be heated in a tube till the organic portion becomes charred, the metallic lead is reduced to a state of extreme subdivision, and usually takes fire when poured into the air. If finely-powdered sulphate of potash be mixed with half its weight of lamp-black, and heated in a covered crucible, the sulphate is reduced to sulphide of potassium, which remains in a finely-divided state, mixed with the excess of carbon, and takes fire spontaneously in the air from the rapid absorption of oxygen. These are amongst the best examples of pyrophori.

Pyrotechny, the art of making fireworks, is of unknown antiquity. It was practised amongst the Chinese from very early times, and has attained with them so much perfection that the beauty and ingenuity of their devices have often been admired by Europeans. Fireworks, as the name is now understood, were hardly known in Europe until the nature of gunpowder became known, and for a long time only very simple pyrotechnic contrivances were used.

The compositions employed for most kinds of fireworks are of the nature of gunpowder. That is to say, the mixtures of which they are made contain combustible or oxidisable substances, along with bodies available for their rapid combustion, since these latter contain large quantities of oxygen. The most frequently employed combustible materials are carbon (charcoal) or some compound of carbon, such as sugar or gum, and sulphur or a compound of this element, such as sulphide of antimony. Such bodies as charcoal and sulphur burn slowly in common air, because its oxygen is largely mixed with nitrogen, which does not support combustion; but when they are compounded with nitrates and chlorates the store of oxygen in these salts being given off by heat enables the firework composition to burn at a more or less rapid rate whenever a spark is applied to it. It is not desirable, however, to have too sudden a union of combustible matter with oxygen, hence violent explosives, like nitro-glycerine, are unsuitable for showing coloured or brilliant flames. The two most important oxidising ingredients used in firework compositions are nitrate and chlorate of potash. Iron, in the form of cast-iron or steel, and in a state of fine division, is a frequent ingredient in fireworks, and to some extent the powder or filings of antimony, zinc, magnesium, and copper are also employed. When the particles of these metals are highly heated they produce sparks and scintillations of different colours. A few substances, such as sand and sulphate of potash, are used to modify the rate of combustion.

Variety of colour is much studied in the production of fireworks, as it contributes greatly to their beauty. The colours usually seen are those given by simple metals when burned. Compounds of the metals form part of the mixtures, and these are reduced to the metallic condition in a state of very fine division by contact with the carbon present in the hot mass. A yellow colour is one of the most easily managed, any of the common compounds of sodium producing it. Copper gives a green colour when burned in a hydrogen flame, which changes to blue in the presence of a little free chlorine; so that when this metal is used for green some substance containing hydrogen is added, and when employed for blue, calomel (one of the chlorides of mercury) is put into the mixture. Nitrate of barium is also employed for green. Salts of strontium give fine crimson tints, calcium com-

pounds a red, and lithium carbonate (a costly substance) a purple red. Among the substances used to produce white colours are sulphide of antimony and sulphide of arsenic.

The cases which contain the firework compositions are carefully made of paper or pasteboard, or both, pasted in layers. They are usually cylindrical in shape, and the proportion of length to diameter, and the size of openings for the escape of the burning mixtures, are matters of importance. So also is the proper mechanical construction of the framework of rotatory fireworks. Touch-paper, prepared with a solution of nitrate of potash in alcohol, is used for capping squibs, crackers, and indeed for all kinds of fireworks; quick-match of cotton-wick, which has been saturated with gunpowder, gum, and other ingredients, connects the parts of complicated designs; and portfires, small pencil-like articles filled with saltpetre, sulphur, and gunpowder, are used to fire the touch-paper cappings.

The simpler kinds of fireworks include squibs, crackers, gerbs, Roman candles, stars, sparks, maroons, theatre-fires, Bengal lights, &c. *Squibs* are small stout paper tubes filled with grained powder, to which a little charcoal, sulphur, and steel filings are sometimes added, a sufficient quantity of bursting powder being put in to cause a slight explosion at the end when fired. *Crackers* consist of a tube bent into folds, and containing meal-powder, charcoal, sulphur, saltpetre, and sometimes iron filings in varying proportions. The folds are tied by a cord; and on a cracker being fired a report is given at every turn of the tube. *Serpents* are tubes, some of which have a choke in the middle. When fired they take a zigzag direction, and give out a hissing noise. *Gerbs* consist of a straight cylindrical case filled with a composition which produces a bright sparkling jet of fire somewhat in the form of a waterspout. They sometimes contain coloured stars. *Roman candles* have a resemblance to gerbs. In filling them stars are placed at intervals along the tube between layers of the composition. *Stars* are of different kinds, such as simple stars, tailed stars, and pointed stars. Simple stars consist of saltpetre, sulphur, and fine gunpowder made into a paste ball with gum and spirits of wine, and dried.

Sometimes they contain iron filings. Many compositions are, however, used for stars, their various colours alone necessitating this. Sparks, or small stars, are also made of different colours. *Maroons* are small boxes, round or square, bound with a cord, and containing a composition which explodes with a loud report. *Bengal lights* consist of compositions varying according to colour, which are burned in small saucers: for example, a red light can be produced by a mixture of chlorate of potash, nitrate of strontia, sulphur, and lampblack; and a green by chlorate of potash, nitrate of baryta, chloride of lead, sulphur, and resin. *Theatre-fires* are produced by slow-burning compositions containing some colouring ingredient. They are burned without cases on a fireproof slab; and all substances obnoxious when burned indoors, such as sulphur, antimony, and arsenic, or their compounds, should be omitted in preparing them. Magnesium powder and the minute spores of one or more species of lycopodium are used to imitate lightning in theatres.

The most complicated kind of fireworks are some of the rotating wheels. These are called wheels because they have a framework of nave and spokes, round the rim of which cases of the nature of rockets are arranged. They revolve on a pin or metal spindle, and the motion is produced, as will be presently explained, by the recoil as the fire escapes from the cases, which are connected with each other by leaders. There are a number of different forms, but they may be classed under three kinds—vertical, horizontal, and spiral wheels. In the case of the last, a rod (nave) rises vertically from the centre of the horizontal wheel, forming the base, and upon this rod cases are arranged so as to form a spiral. *Pin or Catherine wheels* and *pastilles* consist each of a long paper case coiled round a rod in the form of a flat spiral, the case being, of course, filled with a burning composition. *Suns* are either fixed or revolving. Fixed suns are of various designs, but a common kind has a number of cases radiating from a centre, from which jets of fire proceed outwards. By a suitable arrangement the fire is communicated at the same time to the mouths of each of the cases. *Revolving suns* are somewhat similar to fire-wheels with

spokes. Of ascending fireworks the *rocket* is the most familiar, and it has been known from an early period. It consists of two parts—viz. a long stick to guide it in its course, and a head. The latter, of strong paper and cylindrical in shape, has its lower portion formed into a hollow cone, base downwards, and round this cone is the burning composition. The object of the cavity is to effect a rapid combustion, which fills it with heated gases, and these, issuing downwards through a small hole in the base, force the rocket up through the air. The upper portion of the head is separated from the lower by a perforated plug of plaster of Paris, through which a fuse passes, so that when the lower portion is burned, the upper, which has a conical head, takes fire and sets off its garniture of stars, snakes, and other ornaments. When fire-arms are discharged there is a recoil, in the case of a heavy gun, of a short distance; in the case of a light cannon, with a larger charge in proportion to its weight, of a much greater distance; and in the case of a rocket which has a bulky charge in a very light barrel the recoil is great enough to send it high in the air. The motion of a fire-wheel is explained in the same way, there being a recoil caused by the backward pressure of the heated gases on the atmosphere on each case on the ring of the wheel takes fire. The *tourbillion* ascends and rotates at the same time. Upward motion is given by the fire escaping from holes on the under side of the cylinder, and rotatory motion by its finding vent from holes at the ends, but on opposite sides.

Aquatic fireworks, in which the devices which come in contact with the water require to be protected with grease or oil, consist of skimmers or water-devils, floating Chinese trees, gerbs, and Roman candles, water-mines, water fire-fountains, &c. Among recent novelties in pyrotechny are firework-pictures of battles, reviews, and other scenes. Of these perhaps the most popular is the enlargement, in lines of fire, of the portrait of an eminent person in whose honour some public gathering has taken place.

Pyroxylic Spirit, also called **WOOD-SPIRIT** and **WOOD-NAPHTHA**, is a mixture of acetone, methyl-alcohol, acetate of methyl, &c., obtained by the destructive distillation of wood in the manufacture of Pyroligneous Acid (q.v.). Many of its properties are the same as those of common alcohol; and now, notwithstanding a long opposition from the Revenue Board, its manufacture and importation are regularly allowed. It is of nearly equal value to alcohol in making varnishes, as it dissolves the resins, oils, and other similar substances. It has a peculiar naphtha-like odour, which is inseparable from it, and prevents its use as a potable spirit at present; but it is asserted that some makers produce it almost odourless, and that it sometimes takes the place of common alcohol in the manufacture of cheap perfumes. It is used in making Methylated Spirit (q.v.).

Quack Doctors. Medical quackery is a product of all countries and of all ages; it flourishes among civilised and uncivilised communities alike, and was as rampant before the Christian era as it is in our own day. At all times it has found a numerous public ready and willing to be gulled, and this not only among the illiterate and vulgar, but even specially among the higher and better educated classes. In many cases royalty itself has set the fashion by lending its patronage to notorious charlatans. An exact definition of what constitutes medical quackery is not easy to give. The term 'quacksalver,' in use in the 17th century for quack doctor, seems to be derived from the Dutch *kwakzalver* (Ger. *quacksalber*), meaning a person who praised loudly his own medicines or methods of cure. The first part of the word is derived from the well-known but unmusical note of the duck, and typifies the hoarse blatant tones in which itinerant medicine vendors are accustomed to laud their wares. The equivalent French term is *Charlatan*, derived from the Italian *ciarlatre*, 'to chatter' (Lat. *circulari*; *circulator*, 'a pedlar or mountebank')—a name which also indicates their characteristic and persistent loquacity. In more ancient days the loquacity and persistence were verbal; now they are both verbal and literary, as is shown in the deluge of advertisements with which medical quacks flood the world.

Quackery may be taken to include all devices—

whether practised by legally qualified medical practitioners or by those who have had no recognised medical training—which tend to deceive the public by disseminating false ideas of disease, or a belief in imaginary ailments, which vaunt certain medicines or methods of treatment as panaceas or cure-alls, or which attribute to an individual a supernatural or exceptional power of influencing and curing disease. The element of pecuniary gain or of personal vainglory also comes into a definition of quackery, as opposed to the singleness of purpose and devotion to the interests of the patient which are traditionally held to be the guiding principles of the orthodox practitioner of medicine. Perhaps the most amusing description of quacks and their methods has been given by Goldsmith in his *Citizen of the World*, and it is as true and as trenchant to-day as it was then. He says: 'Whatever may be the merits of the English in other sciences, they seem peculiarly excellent in the art of healing. There is scarcely a disorder incident to humanity against which they are not possessed with a most infallible antidote. The professors of other arts confess the inevitable intricacies of things, talk with doubt, and decide with hesitation. But doubting is entirely unknown in medicine; the advertising professors here delight in cases of difficulty; be the disorder ever so desperate or radical, you will find numbers in every street, who, by levelling a pill at the part affected, promise a certain cure without loss of time, knowledge of a bedfellow, or hinderance of business. When I consider the assiduity of this profession their benevolence amazes me. They not only in general give their medicines for half value, but use the most persuasive remonstrances to induce the sick to come and be cured. Sure there must be something strangely obstinate in an English patient who refuses so much health upon such easy terms.'

The Sieur de Courval, writing in 1610, gives a lamentable account of the way in which France, Germany, and Italy were overrun with medical quacks in his day. He describes them as being apostates, vagabonds, disgraced clergy, women of loose character, and rascals of all kinds, and says that they are more dangerous to mankind than vultures, for the latter devour only the dead, while the former prey upon the living. Cadet de Gassicourt, classified quack doctors in a whimsical manner in groups, families, and species, of which the following is an abridgment. *Circulatores*: Insects, very venomous, of the order of suckers; common everywhere, found in all countries and all latitudes. Their external characters are very varied. Some have brilliant elytra, velvety, and studded with gold; others have them more coarsely formed, dull, not entire, and marked with rents. Their intestines have an enormous capacity, the heart is wanting or very small; they attack man exclusively, their stings being always injurious and sometimes mortal. The sting is sometimes very evident, sometimes quite hidden or little apparent. He divides them into two great groups, the *Circulatores Phanerorhynchi*, or peripatetic quacks who practise in public, and the *Circulatores Cryptorhynchi*, or *Charlatans en Chambre*. The latter are described as 'the charlatan of the aristocracy, of the bourgeoisie, and of those who do not wish to be seen consulting him in public. This honest son of toil is imbued with a sense of his own importance, his language is sententious, he speaks with assurance, and is lodged luxuriously. He is often a specialist,' and so on. These two groups are further largely subdivided, and an amusing description given of each species.

The methods of quack doctors have been the same from all time, and consist principally in attracting and impressing public attention by extraordinary surroundings and behaviour, and in loudly and persistently asseverating the virtues of their nostrums. This is essentially advertising; and while the invention of printing has stimulated many industries, there are few which it has benefited to a greater extent than that of the quack doctor, as it at once opened the way to a much wider public. The enormous modern spread of newspaper reading has further been largely turned by the quack to his own advantage, as it opens up a still wider field for the puffing of his wares. When once public attention has been caught, the battle is more than half won; patronage, popularity, and success follow almost as a matter of course. Fortunately these are frequently of a very temporary character; but, as quack doctors are

essentially a migratory tribe, this drawback troubles them comparatively little. When they return to their old haunts a new crop of dupes is certain to have come up. The success of quacks must be attributed largely to an imperfect knowledge among the general public of what constitutes disease, added to which there is often an implicit faith in the curative power of drugs. There is little popular conception of what is possible or impossible in the way of healing, and thus the most absurd and extravagant statements are received as facts. Their success, however, has a deeper origin—viz. in the most potent of all human passions—the desire to preserve life. The strong desire for life, health, and the relief of pain clouds the judgment and causes the chance of relief from any source to be eagerly grasped at. The popular love of the marvellous and mysterious has also been of great assistance in pushing the fortunes of many quacks.

Quack medicines, as a rule, form no real additions to our means of treating disease. Almost without exception they are formulae taken from some old or modern pharmacopœia, or the prescription of some well-known physician, christened with a name calculated to strike the popular fancy, and then puffed and advertised into fame. Such remedies are to be found for every real and imaginary ailment of mankind; but the happy hunting-ground of the quack is more especially in the regions of chronic, but not fatal, disease, such as the multifarious rheumatic affections, chronic skin affections, asthma, hysteria, hypochondriasis, 'nervous disorders,' and a host of others. Persons afflicted with such ailments have naturally alternations of good, bad, and indifferent health, and are often very prone to attribute what is simply natural improvement to the action of the remedy last taken. It is such people who certify so confidently and so gratefully to the curative powers of quack medicines. Cures for cancer, sterility, and consumption, various elixirs of life and youth, and single antidotes efficacious against all poisons must alone have made the fortunes of many thousands of quack doctors. The sad part of the whole matter is that mankind never seems to learn by experience; no new methods of deception are introduced, no real originality or inventive enterprise is ever shown by quacks; they rely upon exactly the same old artifices as their predecessors did, and generation after generation are duped by them just as surely.

Quills are the large feathers of the wings of birds, certain kinds of which have for centuries been used to make into writing-pens. From the swan, goose, and turkey the kinds are obtained that are regularly prepared for writing purposes, crow quills being used for drawing. A quill, like horn or hair, is formed of epidermic tissue, and the barrel or tube (the quill proper) has an external membrane and an internal pith. In order to get rid of these, and to bring the naturally soft state of the barrel into a condition ready for making into a pen, it requires to be dressed. The quill-dresser sits beside a fire enclosed with brick sides and with an iron face-plate in front, containing a hole somewhat larger than a crown piece. He first heats the quill by placing it for one or two seconds in this hole, which enables him to scrape off the outer membrane with a thick strong knife, the quill being pressed nearly flat in the operation. This done, he again holds it for a brief time in the furnace, by which the quill acquires the proper strength and brittleness to admit of its being made—by a knife or machine—into a pen with a clean slit. Quills were formerly prepared for writing by another process, which is still used for such as are made into toothpicks. This consists in steeping them for a night in water and then manipulating them in hot sand. Although the manufacture of quill-pens is a declining industry, they are still made in considerable numbers.

Quinine is an alkaloid having the chemical formula $C_{20}H_{21}N_3O_7 \cdot 3H_2O$. Along with cinchonidine, cinchonine, and a large number of other alkaloids, it is present in the bark of numerous species of *Cinchona* and *Remijia*, of which these substances constitute the active medicinal principles. Good barks yield an average of 5 to 6 per cent. total alkaloids, of which one-half is quinine and cinchonidine, the other half consisting of the

other alkaloids in varying proportions. Quinine is by far the most important from a medical and commercial point of view; the yield of it varies greatly, 1½ and 8 per cent. being the extremes. Quinine is obtained from the powdered bark by treating it with lime, and then extracting the mixture with alcohol, neutralising with an acid so as to obtain a salt of quinine, and finally purifying the product. In 1820 Pelletier and Caventon isolated pure quinine, and demonstrated that it was the chief active ingredient in the bark. Many attempts have since been made to prepare it artificially, but without success. For the introduction of the bark into Europe, and the culture of the tree in South America and (recently) in India, see CINCHONA.

Quinine itself is not used in medicine, owing to the inconveniences arising from its insolubility in water, but many of its salts are, and two of them, the sulphate and hydrochlorate, are included in the British Pharmacopœia along with numerous preparations of cinchona-bark containing them. The sulphate is the most commonly used preparation, and it is popularly known as quinine. It occurs in small, silky, snow-white crystals, which have a purely and intensely bitter taste, and are sparingly soluble in water (1 in 700 parts); its solutions have a bluish or fluorescent colour even when very dilute. In alcohol or dilute sulphuric acid it is very soluble. The hydrochlorate closely resembles the sulphate, but is much more soluble in water (1 in 34 parts), and its solutions are not fluorescent. When treated with excess of chlorine water and a few drops of ammonia solution, solutions of quinine give a clear emerald green colour; if ferrocyanide of potassium be added this changes to a ruby red.

Preparations of quinine, and especially the sulphate, are very largely used in medicine. Locally applied dilute solutions (2 to 4 gr. to the oz. of water) have a germicidal, antiputrefactive, and antifermentative action, hence they are used as lotions in hay fever, diphtheria, cystitis, and similar diseases. As a bitter tonic small doses (½ to 2 grains) are frequently given in general debility, atonic dyspepsia, anaemia, scrofula, convalescence from acute diseases, and other conditions where tonic treatment is required. It is also of great value as an antipyretic and antiperiodic. In healthy persons it does not reduce the bodily temperature, but in typhus, typhoid, rheumatic, and some other fevers it is extremely valuable in this respect. A dose of 3 to 15 grains may be given in these cases. In certain fevers it does not reduce temperature. In malarial affections of all kinds it is supreme, and at present no other known drug can compare with it in efficacy. In intermittent fevers and ague the best plan is to begin its administration about eight hours before the attack is expected, and continue it in hourly doses for three or four hours until 15 to 30 grains have been given. It cuts short or aborts the recurring febrile attacks. It is also of great value as a prophylactic in persons who are exposed to the risks of malarial poisoning. In such cases three grains twice daily is usually considered a sufficient dose.

Quinine is also largely given in neuralgia and in inflammations. Large doses are very apt to irritate the stomach, and sometimes produce a train of symptoms known as cinchonism. There is singing in the ears, dizziness, deafness, a feeling of fullness in the head, and disturbance of vision—all of which usually pass off without leaving any ill results. In some cases the effects are more severe, and may lead to dangerous depression and collapse, especially if the patient be already weakened by disease. Certain persons are very susceptible to the action of quinine, and suffer from cinchonism after small doses. In others skin eruptions, oedema of the face, irritation of the bladder and kidneys, and other disagreeable effects are sometimes seen. Workers in quinine-factories also occasionally suffer from skin eruptions. These accidents are, however, comparatively rare.

The sulphate of cinchonidine and sulphate of cinchonine are also included in the British Pharmacopœia. They have the same actions and uses as quinine, but are very much less used. They seem, however, to be efficacious, and are cheaper.

Quinoline, a pungent colourless liquid obtained by the distillation of bones, coal-tar, and various alkaloids. It is the base of many organic bodies, and is isomeric with Leucol (q.v.).

Radical, in Chemistry, is a term applied to a

group consisting of two or more elementary atoms which is capable of entering into a series of different compounds without itself undergoing change or decomposition. In this respect a radical resembles an atom of an elementary substance. Radicals are, in a sense, incapable of a separate existence, and must be in combination with other radicals or elements. Two similar radicals can, however, combine with each other, and in such cases the compound produced has been looked upon as the radical in the free state.

The radical methyl, CH_3 , consisting of one atom of carbon and three atoms of hydrogen, is known in combination with chlorine, iodine, oxygen, and sulphur in the respective compounds, methyl chloride, CH_3Cl , methyl iodide, CH_3I , methyl oxide, $(\text{CH}_3)_2\text{O}$, and methyl sulphide, $(\text{CH}_3)_2\text{S}$. Two methyl groups occur in combination with each other in the substance ethan or dimethyl, $(\text{CH}_3)_2$ or C_2H_6 . A very large number of other compounds contain the radical methyl.

The sulphates, the nitrates, and the acetates contain the respective radicals SO_4 , NO_3 , and $\text{C}_2\text{H}_3\text{O}_2$. These are frequently called the *salt-radicals* of the respective series of salts. In double decompositions the salt-radical occurring in combination with one metal is transferred, without decomposition, to another metal. For instance, the equation



represents the mutual exchange of salt-radicals by the metals magnesium and barium.

In chemical notation short symbols are frequently employed to represent complicated radicals. Thus, the complex salt-radical of the tartrates, $\text{C}_4\text{H}_4\text{O}_6$, is shortly represented by the symbol T . Tartaric acid is then represented by H_2T , potassium tartrate by K_2T , potassium hydrogen tartrate (cream of tartar) by KHT , &c.

Rain-gauge. Rain-gauges measure the quantity of rain which falls, and are of various constructions. One of the best is that known as Symons' rain-gauge, consisting of a funnel-shaped receiving vessel, and a glass measure of much smaller diameter so as to allow as nice graduation as may be desired. In the fig. *a* is the funnel-shaped receiving vessel (shown in section in the fig.), 5 inches in diameter, with an upright, sharp-edged and strong rim, in order that it may retain its circularity; *b*, the vessel which receives the rain collected; and *c*, the graduated glass measure which measures the amount in tenths and hundredths of an inch. If desired it may be graduated to still greater nicety. Another excellent gauge is one which is a modification of Glaisher's gauge, brought into use by the Meteorological Office. The diameter of this gauge is 8 inches, and there is added to it a vertical cylinder on the top of the receiving funnel, to retain the snow as it falls and prevent its being blown out of the gauge, as is likely to happen when the funnel is shallow. Beckley's is perhaps the best continuously recording rain-gauge, and is now very generally superseding Osler's so long in use.

Since different amounts are collected at different heights above the ground, it is indispensable, if uniformity and comparability is to be attained, that the rims of rain-gauge be placed at one uniform height above the ground. The height now generally adopted is 12 inches. The points it is necessary to secure at the height adopted are (1) the prevention of in-splashing as the rain-drops strike the ground and are broken into minute droplets, a large number of which in their second descent fall into the gauge; (2) the prevention of out-splashing, which occurs when the funnel is very shallow; and (3) the protection of the gauge as much as possible from strong winds, which so

seriously interfere with the amount collected, by placing it as near the ground as can be done consistent with the prevention of in-splashing. These conditions are best fulfilled by using the gauges named, and placing their rims 12 inches above the ground. It has been proved from carefully conducted experiments that rain-gauges with diameters varying from 3 inches upwards collect amounts, when in positions exactly similar, within about 3 per cent. of each other. Accordingly, gauges with diameters exceeding 8 inches insure no greater accuracy than smaller ones, being only really required in the case of continuously recording gauges to hold the self-registering apparatus. On the other hand, gauges of from 3 to 5 inches diameter, such as Fleming's and Jagga's, give good trustworthy results.

Special care should be taken that the gauge and its glass measure be kept clean; that it be firmly fixed and the rim kept in a horizontal position; and that it be made of a material which will stand exposure to the weather well. It should be placed in a situation as open as can be secured for it, particularly towards the directions from which the rain chiefly comes; and in each case it should be as distant from any neighbouring house, tree, or other object at least as far as the height of the object itself.

Rape is having carnal knowledge of a woman without her conscious consent, and such consent must not be extorted by violence or threats of violence. The Criminal Law Amendment Act, 1885, provides that a man is guilty of rape if by personating a woman's husband he succeeds in having connection with her. Previously the point was doubtful. A husband cannot under any circumstances commit rape on his own wife, her consent at marriage being irrevocable; but Mr Justice Stephen is of opinion that under certain circumstances he may be convicted at least of an indecent assault. Nor can a boy under fourteen be guilty of this crime, for in law (whatever be the physical fact) he is absolutely presumed incapable; but both husband and boy may be charged with assisting others in committing it. Rape is a felony punishable with penal servitude for life. To this every one who unlawfully and carnally knows any girl under the age of thirteen years is also liable. The attempt to have unlawful carnal knowledge of any girl under thirteen, and the act or attempt in the case of a girl between thirteen and sixteen (save when the accused reasonably believes her to be over sixteen), or in the case of any female idiot 'under circumstances which do not amount to rape,' are misdemeanours, punishable by two years' imprisonment with hard labour. The merest penetration suffices to constitute the crime. As regards evidence in cases of this sort, the most important question will usually be, How far is the supposed injured person to be believed? That depends on many things, of which the chief are (1) her character—for though as a matter of law rape may be committed on a prostitute, since even she cannot be compelled to submit to outrage, yet in fact if the chief witness is shown to be unchaste the charge almost invariably breaks down; (2) the time within which and the person to whom she made the first complaint; (3) any marks of violence on her dress or person, and her agitated or calm demeanour; (4) the scene of the alleged crime, and the probability of strenuous resistance attracting public notice; (5) whether the prisoner fled or not; (6) any marks of violence on his dress or person. (7) If apprehended soon after the alleged act the accused is usually asked to submit to medical examination. Refusal to do so is a strong presumption of at least intercourse. The thing to be guarded against is either a false charge made by a woman to extort money or, on failure of this attempt, persisted in from spiteful motives, or an accusation made by one who after consenting resists too late, or who tries when by any accident the fact of connection becomes known to whitewash her character.

The law which protects women against the class of crime of which rape is the chief has been made much wider of late years, chiefly by the Criminal Law Amendment Act of 1885, which contains provision against various kinds of procuration. As regards the abduction (1) of a woman on account of her fortune; (2) by force with intent to marry; (3) of an unmarried girl under the age of eighteen with intent to have carnal knowledge of her, it need only be remarked that the first two are felonies punishable by fourteen years' penal servitude, and

the third a misdemeanour punishable by two years' imprisonment with hard labour.

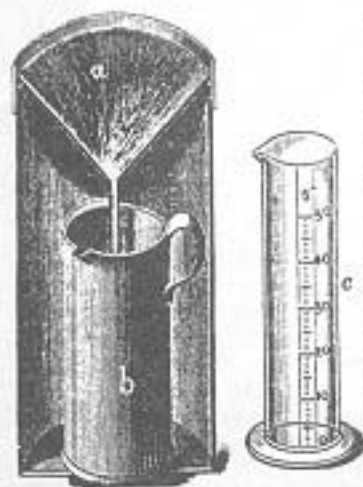
In the United States the crime is everywhere treated as a felony, and punished with imprisonment for life or for a number of years; but the punishment is somewhat different in the different states of the Union.

Rat, a name applied to the larger species of the rodent genus *Mus*, but especially to the Brown Rat (*M. decumanus*) and the Black Rat (*M. rattus*). Like the mice, which are included in the same genus, rats are agile and graceful animals, skilful in burrowing, predominantly nocturnal. The bright eyes, large ears, naked muzzle, soft fur, and long scaly tail are familiar external characteristics. The brown or Norway rat measures about eight inches in length, not including the tail, which is usually shorter than the body. It is grayish-brown in colour, with flesh-coloured ears, feet, and tail. Black varieties sometimes occur. It is believed to have travelled gradually westwards, perhaps from China, and did not reach France or Britain till towards the middle of the last century. In 1727 swarms swam across the Volga, and rapidly spread over Europe, displacing the black rat which had arrived some centuries before. According to some, the black rat was brought to Britain in 1732 in ships from the East Indies. As a common stowaway in ships, it has been distributed over the world, reaching America about 1775. The black rat is smaller and slimmer than the brown rat. The head and body measure six or seven inches in length; the tail is an inch or two longer. The head is more slender than in the brown rat, and the ears are rather larger. In most the colour is glossy black, but white and piebald varieties may occur. It is less fierce than the brown rat, and seems to be less distinctively a burrowing rodent, preferring the upper parts of houses to the cellars. Its original home seems to have been in the East, perhaps in Persia, but it must have reached northern Europe by the 13th century at least, for its troublesome presence is noticed by Albertus Magnus.

These species of rat have similar habits, and the stronger, larger, and fiercer form sometimes tends to exterminate the other, this being one of the few instances which Darwin gives of his conclusion that the struggle for existence is keenest between closely allied species. As to the habits of rats, it is well known that they find their way everywhere; no door is shut to them; they gnaw and burrow through almost all obstacles. They run and leap, they climb and swim. They are fond of animal food, but will eat almost anything; corn, fodder, all kinds of human food, eggs, young birds, small mammals, all is grist to their mill. In illustration of their voracity it is often related that in a slaughter-house near Paris thirty-five dead horses were picked to the bones in a single night. When pressed by hunger they display much boldness, and their skill in stealing even such unmanageable



Black Rat (*Mus rattus*); Brown Rat (*Mus decumanus*). goods as eggs is well known. Their senses, especially of smell and hearing, are acute, and their intelligence is well developed. The mothers are careful of their tender offspring, but the males display the reverse of parental affection. The albinos are delightful pets. Brehm cites several strange observations in regard to the so called 'rat-kings,' which consist apparently of a number of diseased rats with entangled tails. It is said that over two dozen individuals have been found thus entangled. Rats are very prolific, breeding four or five times a year. Four to ten young are brought forth at a birth, after a very short gestation of about three



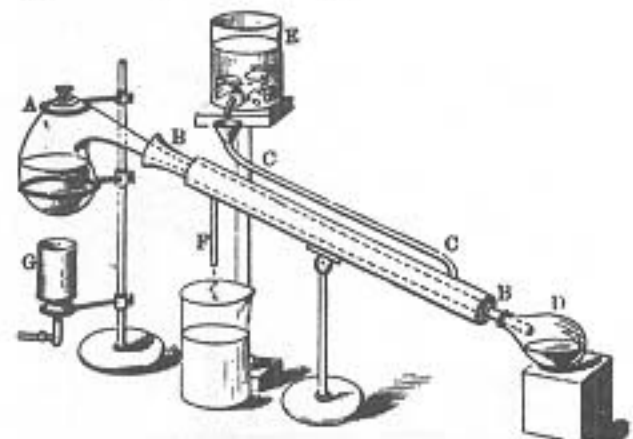
Symons' Rain-gauge.

weeks. Moreover, the young become sexually mature in about six months. All the conditions favour rapid increase, and plagues of rats by no means easy to cope with not unfrequently occur. Rats do much damage in various ways—by their burrows, by their voracious gnawing of all sorts of things, by their omnivorous appetite. They undermine walls, destroy woodwork, devour stores. When pressed with hunger they may attack large mammals, and even man himself sometimes falls a victim. They have been known to eat holes in fat pigs, to gnaw off the legs of birds, and even to destroy the soles of elephants' feet. Their destruction may in many cases be left to their natural enemies—birds of prey and carnivorous mammals—but it is often necessary to resort to the use of traps and poisons. One of the most effective ways of destroying them is to feed them with a mixture of meal and plaster of Paris. Their skin is sometimes used for making glove-leather; and their flesh, according to *The Farmer's Friends and Foes*, by Theodore Wood (1887), is, if similarly cooked, superior to rabbit.

There are several genera nearly related to *Mus*—e.g. *Nesocia*, of which an East Indian species, the Bandicoot-rat (*N. bandicota*), may measure over a foot in length; *Haplotis*, represented by little jerboa-like animals in Australia; *Echinotrix*, with one species in Celebes, a rat with a very long muzzle, and spines among the fur; *Cricetomys*, represented by a formidable African species (*C. gambianus*) of large size and ferocious voracity. To some more remotely related rodents the term rat is often popularly applied—e.g. to the Water-vole (*Arvicola amphibius*; see *VOLE*), and to the American Musk-rat (*Fiber zibethicus*).

Rennet (A.S. *rinnan*, *rennan*, 'to run') consists of the inner lining of the true stomach (see *DIGESTION*) of the sucking-calf. It contains a ferment which causes milk to clot (see *MILK*), called the milk-curdling-ferment. The rennet is used in the manufacture of cheese, and to a less extent in the preparation of curds and whey or junket. It is prepared by removing the stomach from the calf as soon as it has been killed, and separating off the lining membrane of the stomach. It is then salted and dried, and will keep for some time in that condition. When used, a small piece of the rennet, in which the ferment is still quite active, is softened in water and added to the milk which is to be curdled. For many years past the milk-curdling-ferment has been obtained from rennet in the form of an extract. It is soluble in salt and water, and is extracted from the fresh rennet of the calf, and kept from putrefying by the addition of alcohol. Extracts of rennet thus prepared are extensively used, and may be had at the druggists' stores.

Retort, a vessel employed by chemists for the purpose of distilling or effecting decomposition by the aid of heat. It may be made of glass, earthenware, or metal, according to the purposes for which it is to be employed. Glass retorts are the most common, and their ordinary form is seen in the figure. They may be employed for the production



Retort fitted with Liebig's Condenser:

A, bulb of the retort, into which the liquid to be distilled is put; D, the receiver, into which the end of the retort is placed; BB, the condenser, receiving a supply of cold water from F by means of the pipe C, the heated water escaping at F; G, the heating apparatus, a Bunsen burner in this case.

of such products as do not require any extraordinary degree of cold for the condensation of their vapour—as, for instance, for the production of hydrocyanic or nitric acid. The globular vessel in which the neck of the retort is inserted is from its function

termed the *receiver*. Cold may be applied to the neck of the retort—for the purpose of condensing the vapour—in various ways, as by the application of a cold wet cloth, by a current of water, or by a special apparatus known as *Liebig's Condenser*, shown in the figure at BB.

In ordinary cases requiring a higher temperature than glass could bear earthen retorts are used; for the preparation of hydrofluoric acid retorts of lead are employed; while for the preparation of strong sulphuric acid platinum is the best material for the retort. Iron retorts are employed in the laboratory for the preparation of oxygen from black oxide of manganese and some other processes, and in gas-works for the destructive distillation of coal. See *DISTILLATION*.

Reverberatory Furnace, a furnace so constructed that ores and other materials may be heated in it without coming in direct contact with the fuel. It consists essentially of three parts—viz. a fireplace at one end; in the middle a flat bed or sole, on which the material to be heated is placed; and at the other end a chimney to create a draught and to carry off the smoke or fume. Between the fireplace and the bed a fire-bridge is placed, and the whole built over with a flat arch, dipping towards the chimney. The flame plays over the fire-bridge, and the heat is reflected, or *reverberated*, on the material beneath; hence the name. See *COPPER*, *LEAD*, and *IRON* (puddling furnace).

Ribs are elastic arches of bone, which, with the vertebral column behind, and the sternum or breast-bone in front, constitute the osseous part of the walls of the chest. In man there are twelve ribs on each side. The first seven are more directly connected through intervening cartilages with the sternum than the remainder, and hence they are termed *vertebro-sternal* or *true ribs*; while the other five are known as *false ribs*, and the last two of these, from being quite free at their anterior extremities, are termed *floating ribs*. A glance at a skeleton, or at a plate representing the articulated

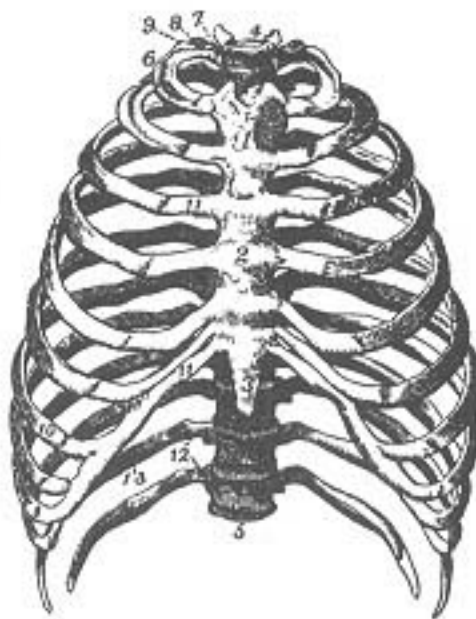


Fig. 1.—The Ribs, *in situ*:

1 and 2 are the upper and the middle parts of the sternum or breast-bone; 3, its ensiform cartilage; 4, the first dorsal, and 5 the last (or twelfth) dorsal vertebra; 6, the first rib; 7, its head; 8, its neck, resting against the transverse process of the first dorsal vertebra; 9, its tubercle; 10, the seventh or last true rib; 11, the costal cartilages of the true ribs; 12, the last two false ribs or floating ribs.

bones, will show that the ribs vary very considerably both in their direction and size. The upper ribs are nearly horizontal, but the others lie with the anterior extremity lower than the posterior; this obliquity increasing to the ninth rib, and then slightly decreasing. They increase in length from the first to the eighth, and then again diminish. The spaces between the ribs are termed the *intercostal spaces*. On examining a rib taken from about the middle of the series we find that it presents two extremities (a posterior or vertebral, and an anterior or sternal), and an intervening portion, termed the body or shaft. The posterior extremity presents a head, a neck, and a tuberosity. The head is marked by two concave articular surfaces divided by a ridge, the lower facet being the larger. These surfaces fit into the cavity formed

by the junction of two contiguous dorsal vertebrae, and the ridge serves for the attachment of a ligament. The neck is a flattened portion proceeding from the head; it is about an inch long, and terminates at an eminence termed the tuberosity or tubercle, from whence the shaft commences. On the lower and inner part of this tubercle is a small oval surface, which articulates (as shown in fig. 2) with a corresponding surface on the upper part of the transverse process of the lower of the two vertebrae with which the head is connected. The shaft presents an external convex and an internal concave surface. A little external to the tubercle the rib is bent to form the angle, from which point the rib passes forwards and outwards, ultimately curving inwards to join its costal cartilage. The upper border of the rib is thick and rounded, while the lower border is marked by a deep groove, which lodges the intercostal vessels and nerve.

The ribs of Mammals are mostly connected, as in man, with the bodies of two vertebrae, and with the transverse processes of the posterior one. In the Monotremata, however, they articulate with the vertebral bodies only; while in the Cetacea the posterior ribs hang down from the transverse processes alone. Their number on each side corresponds with that of the dorsal vertebrae. The greatest number, twenty-three, occurs in the two-toed sloth, while in the Cheiroptera eleven is the ordinary number. In Birds each rib articulates by means of a small head with the body of a single vertebra near its anterior border, and with the corresponding transverse process by means of the tubercle. Moreover, each rib possesses a 'diverging appendage,' which projects backwards over the next rib, so as to increase the consolidation of the

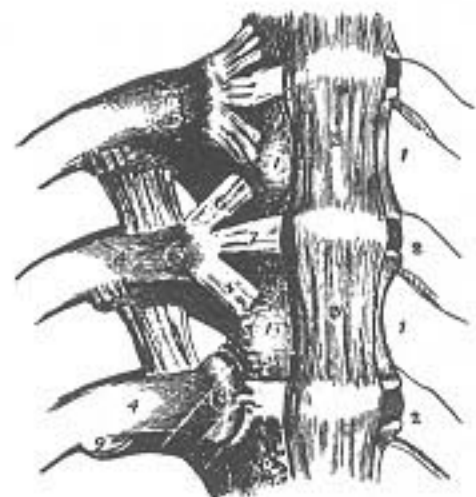


Fig. 2.—A Front View of the Articulations of the Ribs with the Spinal Column:

1, 1, dorsal vertebra; 2, 2, intervertebral cartilages; 3, 3, anterior common ligament; 4, neck, and 5 head of rib; 6, 7, 8, flat bundles of ligamentous fibres (removed in the lowest rib, shown in the figure); 9, articulation between the tubercle of the ribs and the transverse vertebral process.

thoracic framework, necessary for flying. The dorsal vertebrae here never exceed eleven, and are commonly seven or eight in number, and the ribs proceeding from them are connected with the sternum not by cartilage, as in mammals, but by true osseous sternal ribs, which are regularly articulated at one end with the sternum, and at the other with the termination of the spinal ribs. In the Chelonian Reptiles the ribs (as well as the vertebra and the sternum) deviate remarkably from the normal type, the lateral parts of the carapace consisting mainly of ankylosed ribs united by dermal plates. In the Crocodiles there are only twelve pair of true or dorsal ribs; while in the other Saurians, and in the Ophidians, the ribs are usually very numerous. In the Frogs there are no true ribs, the reason probably being that any bony element in their thoracic walls would interfere with the enormous thoraco-abdominal enlargement which these animals periodically undergo at the breeding period.

In the language of the comparative anatomist, a rib is to be regarded as a *Pleurapophysis*—one of the elements of a typical Vertebra (q.v.).

Fracture of the Ribs is a very common surgical accident, resulting from blows or falls upon the chest. Ribs may, moreover, be broken by mere pressure, as when persons are severely crushed in a crowd; and instances are on record in which, in the case of aged persons, the ribs have been

actually fractured in violent coughing. The treatment consists in the application of a broad flannel roller round the chest, so tightly as to prevent, as far as possible, all movement of the ribs, and to render the respiration abdominal rather than thoracic. The bandage must be prevented from falling by the addition of shoulder-straps; and in order to prevent the shoulder-blade from moving, and thus disturbing the broken ribs, some surgeons confine the arms to the side of the body. If one or both of the extremities of the fractured rib should perforate both layers of the pleura and wound the lung, or in rare cases when only the parietal layer of the pleura is injured, if the skin is also perforated, air may escape in the act of inspiration from the lung or from the exterior into the pleural cavity, and thence through the wound in the costal pleura into the cellular or areolar tissue of the trunk, giving rise to Emphysema (q.v.), in the form of a soft puffy swelling that crepitates and yields on pressure.

Ringworm (*Tinea tonsurans*) is a disease dependent on the presence of a parasitic fungus, known to botanists as the *Trichophyton tonsurans*, and discovered in 1844 by Malmsten. The fungus consists of a mycelium, or network of threadlike filaments, with oval, transparent spores, about $\frac{1}{16}$ th of an inch in diameter, for the most part connected in chains, but sometimes isolated. When found on the surface of the body the fungus grows in the epidermis; but on the scalp, where it is most common, it is chiefly seated in the interior of the hair-roots. The diseased hairs lose their elasticity and break when they have risen a line or two above the scalp.

Ringworm of the Body (*Tinea circinata*; *Tinea marginata*) first appears as a rose-coloured and slightly-elevated spot about the size of a threepenny-piece, on which a bran-like desquamation of epidermis soon begins, accompanied by slight itching. This spot gradually increases in size, but retains its circular form; and as it extends, the healing process commences at the centre, so that the circular red patch is converted into a ring, enclosing a portion of healthy skin; and a ring thus formed may continue to increase till it reaches a diameter of four inches, or even more. It is apt to affect the face, the neck, the back, and the outside of the wrist. This form of ringworm frequently terminates spontaneously.

Ringworm of the Scalp (*Tinea tonsurans*) usually occurs in children, and is especially prevalent when the nutrition is defective, or there is a scrofulous taint in the constitution. In infants, and after the age of puberty, it is rare, and can usually be readily cured. It appears in the form of round, scaly, irritable patches on different parts of the head; and the irritation often occasions the formation of minute vesicles. The hairs at these spots become dry and twisted, and are easily removed, but when

the disease advances they break close to the scalp if an attempt is made to extract them. The stumps, and the epidermis surrounding them, become covered with a characteristic grayish-white powder, consisting of the spores of the fungus. The diseased parts are slightly elevated and puffy, and differ from the healthy scalp in colour, being bluish or slate-coloured in dark persons, and grayish red or yellow in fair patients. The inflammation will last as long as the growth of the fungi continues; and even when they die spontaneously, as sometimes occurs, the affected spots may become bald in consequence of the hair-bulbs having become atrophied. This condition, however, generally passes off in time. In some children only single hairs here and there may become or remain affected, and such cases are particularly apt to lead to the spread of the disease, because they are difficult to detect, and often escape recognition.

Ringworm is also sometimes met with in the beard, giving rise to one form of the troublesome disease known as Sycosis. Ringworm is extremely contagious; and when a case of it occurs in a family or a school strict precautions are necessary to prevent its spreading to others. The greatest care should be taken that no brushes, sponges, towels, caps, &c. touched by the patient are used by others. The hair should be kept short, and the scalp anointed daily with carbolic oil, 1 in 20; a cap of linen or oil-silk should be worn night and day; and whatever remedy is selected should be steadily and perseveringly applied. No child with

ringworm should be allowed to go to school, unless under very special precautions, nor to the hatter or hairdresser; and intercourse with other children should be permitted as little as possible except in the open air.

Treatment.—Ringworm of the body is usually not difficult to cure. The application of some parasiticide, white precipitate ointment, solution of sulphurous acid, tincture of iodine, usually quickly kills the parasite and so ends the disease. Ringworm of the scalp, on the other hand, is often an extremely intractable affection, because the parasite extends deep into the hair-follicles, and it is very difficult to bring the remedies employed satisfactorily in contact with it in this situation. In recent cases the remedies recommended above are often effectual; but those which have become chronic sometimes tax the ingenuity of the physician and the patience of the nurse to the utmost, and may even last till advancing years make the soil unfavourable for the further growth of the parasite.

Ringworm in the lower animals, as in the human subject, consists of the growth of a vegetable fungus on the surface of the skin, is common amongst young animals, is decidedly contagious, and communicable from man to the lower animals, and probably, also, from the lower animals to man. Commencing with a small itchy spot, usually about the head or neck, or root of the tail, it soon spreads, producing numbers of scurfy circular bald patches. It is unaccompanied by fever, and seldom interferes seriously with health. After washing with soap and water, run over the spots lightly every day with a pencil of nitrate of silver, or rub in a little of the red ointment of mercury, or some iodide of sulphur liniment.

Rochelle Salt is the popular name of the tartrate of soda and potash ($\text{KNaC}_4\text{H}_4\text{O}_6 + 4\text{H}_2\text{O}$), this salt having been discovered in 1672 by a Rochelle apothecary named Seignette. It occurs, when pure, in colourless transparent prisms, generally eight-sided; and in taste it resembles common salt. It is prepared by neutralising cream of tartar (bitartrate of potash) with carbonate of soda. After a neutral solution has been obtained, it is boiled and filtered, and the resulting fluid is concentrated till a pellicle forms on the surface, when it is set aside to crystallise. This salt is a mild and efficient laxative, and is less disagreeable to the taste than most of the saline purgatives. From half an ounce to an ounce, dissolved in eight or ten parts of water, forms an average dose. A drachm of Rochelle Salt added to one of the ingredients of an effervescing draught (bicarbonate of soda or tartaric acid, for example) forms one of the varieties of what are called Seidlitz powders.

Rubefacients are external agents employed in medicine for the purpose of stimulating, and consequently reddening, the part to which they are applied. All agents which, after a certain period, act as Blisters (q.v.) may be made to act as rubefacients, if their time of action is shortened. The mildest rubefacients are hot poultices, cloths soaked in very hot water, moderately stimulating liniments—as, for example, soap-liniment, with various proportions of liniment of ammonia, or chloroform, &c. Spanish fly, in the form of *Emplastrum Calefaciens*, or warm plaster, in which the active ingredient is blunted by the free admixture of soap-plaster, resin-plaster, &c., is a good form of this class of agents. Capsicum or Cayenne pepper, in the form of a poultice, is an excellent rubefacient; it is much used in the West Indies, but is seldom employed in this country. Mustard, in the form of *Cataplasma Sinapis*, or mustard poultice, and oil of turpentine are perhaps the best of the ordinary rubefacients. The former is applied to the soles of the feet and the calves of the legs in the low stage of typhus fever, in apoplexy and coma, in narcotic poisoning, &c. It is also applied to the chest, with much advantage, in many cases of pulmonary and cardiac disease, and to the surface of the abdomen in various affections of the abdominal viscera. The best method of employing turpentine is to sprinkle it freely on three or four folds of clean flannel, wrung out of boiling water. The sprinkled surface of this pad is placed upon the skin, and a warm dry towel is laid over the flannel. Two or three such applications will produce a powerful rubefacient effect. Turpentine thus applied is serviceable in all the cases mentioned in the remarks on Mustard, as well as in sore throat, chronic rheuma-

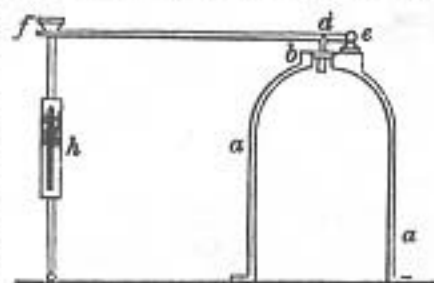
tism, neuralgia, &c.

Saccharic Acid, $\text{H}_2\text{C}_6\text{H}_8\text{O}_6$, is a product of the action of nitric acid, under certain conditions, on grape and cane sugar, or on starch, gum, and lignine. It occurs as a colourless, inodorous, deliquescent, gummy, uncrystallisable mass, which is freely soluble in alcohol. It is sufficiently powerful to dissolve iron and zinc, with extrication of hydrogen. It has a tendency to form double salts. It is dibasic, and forms an acid and a normal salt with potassium.

Saccharimeter, or **SACCHAROMETER**, an instrument for determining the quantity of sugar in liquids, especially brewers' and distillers' worts. In principle it resembles the hydrometer (see SPECIFIC DENSITY), used for ascertaining the strength of alcoholic liquids. It consists of a hollow sphere or oval of thin brass, with a graduated stem and a hook so placed opposite each other that when placed in water it floats, and the graduated stem stands upright on the top, and the hook is below, for the purpose of appending weights. The degree to which the stem sinks gives the means of calculating, by tables prepared on purpose, the proportion of saccharine matter present in the liquid.

Saccharin, or **GLUCIDE**, $\text{C}_6\text{H}_4\text{COSO}_2\text{NH}$, is a sweet substance prepared by complex processes from coal-tar. It is a white, semi-crystalline powder, with a faint odour and intensely sweet taste. So sweet is it that it requires to be very much diluted before its sweetness can be appreciated, from $\frac{1}{2}$ to 1 grain sufficing for a cupful of tea. It is not a pure substance as found in commerce, but contains a variable proportion (40 to 60 per cent.) of a less sweet compound. On this account opinions differ as to its sweetening power compared with that of sugar, it being estimated to be from 200 to 300 times stronger than the natural product. It was at first thought likely that it would prove a serious rival to sugar, but its price offers no great inducement, and conflicting opinions as to its safety have rather militated against its use. At present it is employed for sweetening the food of diabetic patients, and for disguising the taste of drugs. Some aerated-water makers also employ it as a substitute for sugar, and it may be used to give an extra sweetness to glucose in the manufacture of artificial jams, &c. Saccharin is but slightly soluble in water, but dissolves readily if mixed with baking-soda, carbonic acid gas being liberated during solution.

Safety-valve, an apparatus the duty of which is to allow the steam to escape from a boiler when it reaches a certain pressure, and thus to prevent undue strain on the boiler-plates. The figure shows in outline the principle of this valve: *a*, *a* is a dome on the top of the boiler-shell; *b* is a conical brass valve resting on a seat, which has been smoothly bored for its reception; *c* is the fulcrum of a long lever *e*, *f*, from which at *d* there is a projection resting on the top of the valve. The end, *f*, of the lever is held down against the steam-pressure by the spring *h*. The pull exerted by this spring can be adjusted by a nut at *g*, and it is fitted with a brass case, and an index so arranged as always to point to a figure which indicates at what pressure per square inch the steam in the boiler will be able to lift the valve. For most stationary boilers a weight which can be moved along the lever to any desired position is used instead of the spring. In marine boilers the lever is frequently dispensed with altogether, and weights act directly on the valve. It is also usual,



and in steamers compulsory by law, to put two safety-valves on each boiler, one adjustable at will by the engineer, and the other (called the 'government valve') enclosed in a case to which access can only be obtained by means of a key in the possession of the captain. The danger of explosion through overloading the valves is thus obviated. See also STEAM-ENGINE.

Sal Ammoniac, known also as Chloride of

Ammonium, and sometimes as Hydrochlorate of Ammonia, is used in medicine and in chemistry to a considerable extent. It is obtained from the ammoniacal liquor of the gas-works by adding hydrochloric acid and then subliming it in iron pots, or by adding sulphuric acid and then subliming the ammonium sulphate with sodium chloride in the same way; on a small scale it may be made by adding hydrochloric acid to solution of ammonia. It occurs in colourless, odourless, translucent fibrous masses, with an acrid saline taste, and soluble in water. It is used as an expectorant in chronic bronchitis and pneumonia, as a diuretic, diaphoretic, and alterative in rheumatism, and as an alterative in neuralgia; it is also given in catarrhal conditions of the gastro-intestinal tract and in various hepatic diseases. While being dissolved in water it greatly lowers the temperature, and hence in solution can be used as a refrigerant. The dose is 5 to 20 grains given in solution. In chemistry it is largely used as a test. See AMMONIA.

Salicylic Acid, $C_7H_4O_3$, was originally obtained from Salicin (q.v.), but is now made on a large scale from carbolic acid, to which it is very closely allied chemically. It may also be obtained from oil of wintergreen or oil of sweet birch, which consist mainly of salicylate of methyl. It occurs in small white crystals, slightly soluble in cold water; it has no smell, but is very irritating to the nostrils, and causes sneezing; its taste is sweetish and acid. Salicylic acid is used externally as an antiseptic, and as an application in some skin diseases.

For internal use the SALICYLATE OF SODIUM is preferred, as it is much less irritating to the stomach. It occurs in small white crystals, has a sweetish taste, and is very soluble in water. It is used very largely in acute rheumatism, and controls this disease much more speedily and thoroughly than any other drug. It is of less value in chronic rheumatism. It is also employed as an antipyretic, and has been given with some advantage in gout and in diabetes. It is depressant to the heart, and if given in too large doses may induce marked disturbance of the central nervous system, characterised by buzzing in the ears, deafness, and disturbances of vision. More severe results have been noted, but they are very rare. The dose is 10 to 30 grains.

Saline is a term applied to a very popular effervescent powder used as a gentle aperient. It is sold under all kinds of fancy titles, but essentially consists of a mixture of bicarbonate of soda, sugar, and tartaric acid, with a minute trace of Epsom salts or chlorate of potash.

Saliva, one of the digestive fluids, mainly the product of the SALIVARY GLANDS, of which there are three pairs—the parotid, the submaxillary, and the sublingual, with efferent ducts which convey the glandular secretions into the mouth. These, when mixed with the mucus secreted by the follicles of the mucous membrane lining the mouth, constitute the ordinary or mixed saliva. The *Parotid Gland*, so called from the Greek

upon the side of the face immediately in front of the external ear, and weighs from half an ounce to an ounce. Its duct is about two inches and a half in length, and opens into the mouth by a small orifice opposite the second molar tooth of the upper jaw. The walls of the duct are dense and somewhat thick, and the calibre is about that of a crow-quill.

The *Submaxillary Gland* is situated, as its name implies, below the jawbone (part of which is cut away in the figure), and is placed at nearly equal distances from the parotid and sublingual glands. Its duct is about two inches in length, and opens by a narrow orifice on the top of a papilla, at the side of the *frænum* of the tongue. The *Sublingual Gland* is situated, as its name implies, under the tongue, each gland forming a ridge on the floor of the mouth, between the tongue and the lower gums.

It has a number of excretory ducts, which open separately into the mouth. The salivary glands are racemose, or of the compound acinous type (see GLANDS). The recesses which open into the fine terminal branches of the ducts are 'lined and almost filled' by the epithelial cells which secrete the saliva. True salivary glands exist in all mammals, except the cetacea, in birds, and reptiles (including amphibians), but not in fishes; and glands discharging a similar function occur in insects, many molluscs, &c. Saliva contains about one-half per cent. of solids, chiefly salts and mucin. The proportion of its active constituent, ptyalin, is extremely small; and it has never been satisfactorily isolated (see DIGESTION).

The most common disease of the parotid gland is a specific inflammation, which has been already described in the article MUMPS. Tumours of various kinds sometimes occur in front of the ear and over the parotid gland. Their removal is often difficult. Calculi are occasionally formed in connection with the ducts of the salivary glands. *Deficient Secretion* is indicated by clamminess or dryness of the mouth, and is common in low forms of fever. It is important as indicating the condition of the system, and seldom requires treatment. If it should occur as an original affection it must be treated by local Sialogogues (q.v.), such as liquorice, horse-radish, pellitory, &c. *Alteration of the Saliva* is not unfrequent in disease. For example, it sometimes loses its alkaline character, and becomes acid, as in acute rheumatism, diabetes, &c.; whilst in other cases it becomes so foetid as to be a source of annoyance both to the patient and his friends, as, for example, in scurvy, various forms of dyspepsia, salivation, &c. The undue acidity may be corrected by the administration of carbonate or bicarbonate of soda, while the foetid may be relieved by attention to diet, by antiseptic mouth-washes, and by the use, both local and general, of creasote, nitromuriatic acid, charcoal, chlorate of potash, &c. *Ordinary Inflammation* of these glands (distinct from mumps) may proceed from cold or local injury, but it is often produced by decayed teeth.

SALIVATION, or **PTYALISM** (from the Gr. *ptyalon*, 'the saliva'), is the term employed to designate an abnormally abundant flow of saliva. It most commonly arises from a specific form of inflammation of the parotid glands, induced by the action of mercury, in which case it is termed mercurial salivation; but it occasionally appears under the action of other drugs, especially iodide of potassium; and sometimes it occurs without any apparent cause, in which case it is said to be *idiopathic* or *spontaneous*. When mercury is given in such a way as to excite salivation a metallic taste in the mouth is soon recognised by the patient, and a remarkable but indescribable smell, known as the mercurial foetid, may be detected in his breath; the gums become swollen and spongy at their edges, and usually present a few slight ulcers; and an increased flow of saliva takes place, accompanied by pain in the teeth on pressure. If these symptoms be not checked (and *a fortiori* if more mercury be given) the tongue, cheeks, and throat swell and ulcerate, and the saliva that flows away amounts to several pints in the course of the day. Until a comparatively recent period profuse salivation was deemed the only certain indication that the system was duly under the influence of mercury (and, indeed, it was believed that the cause of the disease was carried out of the body with the saliva); but it is now recognised that salivation is harmful, and in administering mercury the object aimed at is not to allow its effect at farthest to go beyond the production of slight tenderness of the gums,

and slight mercurial foetid. Mercurial salivation is therefore very rarely to be seen at the present day. It is worthy of notice that in the confluent form of smallpox there is almost always more or less abundant salivation, which lasts for several days; and if it cease abruptly the peril is usually great. Moreover, there is a more or less marked tendency to salivation in scurvy, hysteria, hydrophobia, some forms of mania, and not unfrequently in pregnancy.

Salt of Saturn, a name for acetate of lead.

Salt of Sorrel, the common name for binxalate of potash. See OXALIC ACID.

Salt of Tartar, a commercial name for carbonate of potash in a very crude form.

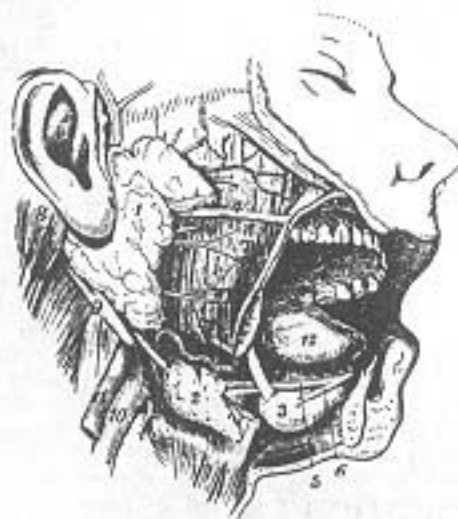
Saltpetre. See NITRE.

Salts constitute an extremely important class of substances in chemistry, of which common or sea salt (sodium chloride) may be mentioned as the most familiar example. Epsom salt (magnesium sulphate), Glauber's salt (sodium sulphate), saltpetre (potassium nitrate), Rochelle salt (sodium potassium tartrate) are other well-known salts. Common salt appears to have been known from the earliest times, and the fact that the same Greek word *hals* is used in the feminine, signifying the ocean, and in the masculine, signifying salt, would seem to indicate the sea as the source from which common salt was obtained in the first instance. The application of the name salt to substances other than common salt would follow from the more or less general similarity of these to common salt in appearance, and in the more easily observed properties, such as solubility, taste, &c.

By the term salt chemists now ordinarily understand a substance which may be looked upon as derived from an acid by the replacement of part or the whole of the hydrogen of the acid by means of a metal or of a Radical (q.v.) capable of playing the part of a metal; such as, for instance, the radical NH_4 , which is called ammonium. The acids themselves are even looked upon as constituting the hydrogen terms in the various series of salts, and are sometimes called hydrogen salts.

There are several general modes of formation of salts. One of the most important of these depends upon the mutual action upon each other of an acid and a Base (q.v.), when the typical characters of each of these substances disappear and a salt is produced, usually with the simultaneous production of water. For example, when nitric acid and the basic oxide of lead act upon each other, lead nitrate and water are produced, thus: $2HNO_3 + PbO = Pb(NO_3)_2 + H_2O$. Salts are also frequently produced when metals are dissolved in acids, the hydrogen of the acid being displaced by the metal. Thus, iron dissolves in dilute hydrochloric or sulphuric acid with the evolution of hydrogen and the formation of a ferrous salt: $Fe + H_2SO_4 = H_2 + FeSO_4$. Strictly analogous to the displacement of hydrogen from sulphuric acid by means of iron is the displacement of copper from cupric sulphate by the same metal—this action also giving rise to ferrous sulphate while copper is precipitated: $Fe + CuSO_4 = Cu + FeSO_4$. In the process called double decomposition (see CHEMISTRY, Vol. III. p. 152) two new salts are frequently produced when the solutions of two salts are mixed together, as, for instance, when sodium chloride and silver nitrate act mutually upon each other, yielding silver chloride and sodium nitrate: $NaCl + AgNO_3 = AgCl + NaNO_3$. There are other modes of salt formation which are of minor importance.

Salts are frequently considered as consisting of metal and salt radical, the latter comprising all that portion of a salt which is not metal, as explained in the article RADICAL. In the cases of the so-called haloid salts (fluorides, chlorides, bromides, iodides) the salt radical consists of one element only, while in other salts the salt radical contains two or more different elements. The names given to certain classes of salts may be shortly explained. Normal salts are those resulting from the displacement of the whole of the displaceable hydrogen of an acid by means of a metal. Neutral salts are such as do not exhibit either the acid or the alkaline reaction when dissolved. Basic salts and acid salts, as contrasted with the normal salts, are respectively intermediate in composition between the normal salt and the base and between the normal salt and the acid. These salts still possess



The Salivary Glands:

1, the parotid gland; 2, the submaxillary gland; 3, the sublingual gland; 4, Steno's duct; 5, Wharton's duct; 6, Bartholin's duct; 7, masseter muscle; 8, mastoid process; 9, digastric muscle; 10, internal jugular vein; 11, external carotid artery; 12, the tongue.

words *para*, 'near,' and *ous*, 'the ear,' is the largest of the three glands occurring on each side. It lies

the respective characters of a base and of an acid. Double salts may contain two or more metals in combination with the same salt radical, or two or more salt radicals in combination with the same metal, or they may contain more than one metal and more than one salt radical.

SMELLING-SALTS are a preparation of carbonate of ammonia with some of the sweet-scented volatile oils, used as a restorative by persons suffering from faintness. The pungency of the ammonia is all that is useful, and the oils are added to make it more agreeable. Oils of lavender, lemon, cloves, and bergamot are those chiefly used. The celebrated Preston smelling-salts are scented with oils of cloves and pimento. The manufacture of ornamental bottles to contain this preparation is an important branch of the glass and silversmith's trades.

Sal Volatile, a well-known remedy for faintness, consists essentially of a solution of carbonate of ammonia in alcohol. It contains in addition free ammonia and the volatile oils of lemon and nutmeg. As it is a strongly caustic liquid, it should never be taken unless well diluted with water. See **SALTS** (**SMELLING**), and **AMMONIA**.

Santonin, $C_{15}H_{10}O_3$, is a crystalline neutral principle extracted from *Santonica*, the latter being defined in the British Pharmacopœia as the dried unexpanded flower-heads or capitula of *Artemisia maritima*, var. *Stechmanniana*. The plant grows in Russia, and belongs to the natural order Compositæ. Santonin occurs in brilliant white flat crystals, which become yellow on exposure to light, few specimens being colourless unless they have been recently prepared or very carefully kept in the dark. It is odourless, and almost tasteless; practically insoluble in water. Santonin is used in medicine solely as an anthelmintic, and is especially poisonous to the round worm (*Ascaris lumbricoides*), being much less so to the thread-worm (*Oxyuris vermicularis*). The dose is 2 to 6 grains for an adult, and 1 to 4 grains for a child; it may be given in powder, alone or mixed with sugar, or dissolved in a little olive or castor oil, or as the official lozenge (1 grain in each). It should be used with caution in weakly children. It is excreted in the urine, to which it imparts a deeper yellow colour, changing to red if the urine become alkaline. On colour vision it has often a peculiar effect, the cause of which has never been satisfactorily determined. Objects appear first purple or blue and then yellow, colour vision becoming finally destroyed.

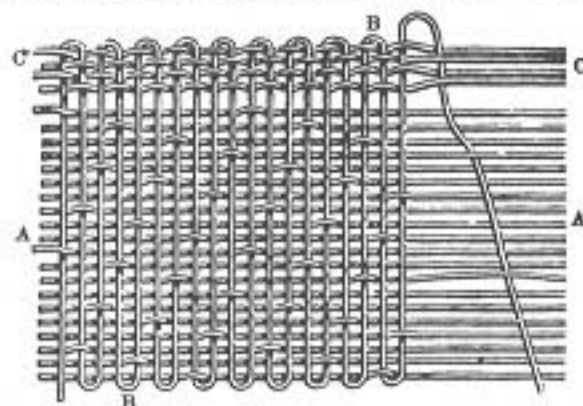
Saponification. See **OILS**, **FATS**, and **SOAP**.

Saponin is a vegetable principle contained in various plants, including the *Saponaria officinalis*, or Soap-wort, the *Polygala senega*, several varieties of *Lychnis*, the fruit of the horse-chestnut, and in *Quillia* bark. It is readily extracted from the root of soap-wort by means of boiling alcohol, which, as it cools, deposits the saponin as an amorphous sediment. It derives its name from its behaviour with water, in which it is soluble in all proportions, yielding an opalescent fluid which froths when shaken like a solution of soap, if even $\frac{1}{1000}$ th part of saponin be present. Its solution, or an infusion of soap-wort, is sometimes employed in place of a solution of an alkaline soap for cleansing the finer varieties of wool from grease. The various preparations for cleaning kid gloves, &c., which are sold under fancy names at every exhibition, owe their virtues to saponin. It is also employed by aerated water makers to give apparent body to their lemonade, &c., the public regarding a persistent head or froth as a guarantee of excellence.

Sarsaparilla, or **SARSA**. This is the dried root of the *Smilax officinalis*, a plant belonging to the natural order Smilacæ, and a native of Central America. In the British Pharmacopœia it is known as *Sarsæ Radix*, or Jamaica Sarsaparilla, being imported from that island, and having first been brought into Europe from the West Indies about 1530. There are, however, several other species of *Smilax* having the same properties, and growing in the warmer parts of America. They are twining shrubs, sometimes attaining a very considerable height, and growing only where there is abundance of water. The root is many feet long, about the thickness of a goose-quill, brownish in colour, with numerous rootlets. They are folded and packed into bundles about 18 inches

long and 4 inches in diameter, bound by a long root. The taste is mucilaginous, slightly bitter and acid; it has no smell. The root contains a crystalline glucoside, *smilacin*, a volatile oil, resin, starch, &c. A decoction, a compound decoction, and a liquid extract made from the root are all official. These preparations act as diuretics and diaphoretics, and are used as alteratives in syphilis, rheumatism, and some skin diseases. Their value is much disputed, and they are not nearly so often prescribed as formerly.

Satin, a fabric in which so much of the weft is brought uppermost in the weaving as to give a more lustrous and unbroken surface to the cloth than is seen when the warp and weft cross each other more frequently; this will be better understood by reference to the figure than by any verbal description. A are the warp threads, of which only every tenth one is raised to allow the shuttle to pass, but they are all raised in regular succession, so that the weaving is quite uniform throughout; B are the weft threads; and C is the selvage, which is formed on each side of the piece of stuff



by the regular method of plain weaving—that is, by raising every other warp thread for the passage of the weft. The figure shows a ten-thread satin twill, but there are various others made, such as a five, a six, a seven, and an eight-thread satin. The lowest satin twill that can be produced is a four-thread, which is sometimes called the satin twill. The term satin is rarely applied to other than silk textiles (see **SILK**). A cotton, and sometimes even a woollen, fabric woven in the way described is called sateen.

Sauerkraut, a preparation of the common white cabbage, in extensive use in Germany and the north of Europe. The cabbages are gathered when they have formed firm white hearts, are sliced or cut fine, and then placed in a succession of thin layers in a cask, each layer being sprinkled with fine salt, to which some add juniper-berries, cummin-seed, caraway-seeds, or other condiment. A board is placed on the top, with a heavy weight, so as to press the whole down firmly, but gently; and ere long fermentation takes place. Sauerkraut is generally eaten boiled, in the same way as fresh cabbage, but is sometimes sweetened. Sauerkraut is also made of red cabbage.

Sawdust. Besides being very useful for such purposes as cleaning dusty floors and stuffing such articles as dolls and cushions, sawdust is turned to account in other ways. Oxalic Acid (q.v.) is manufactured on a large scale from this 'waste' material. The process consists in first fusing sawdust with a mixture of the hydrates of potassium and sodium in iron pans. The gray or brown powder thus obtained is then treated with water, which leaves the sodium oxalate undissolved. This salt is boiled with milk of lime, the resulting calcium oxalate being then decomposed with sulphuric acid and the filtrate evaporated to yield crystals of oxalic acid. Sawdust is also used in the 'carbonating' stage of the process for the manufacture of soda ash. The substance called *Bois-durci*, of which beautiful ebony-like medallions and other ornaments are made, consists of the fine sawdust of rosewood, ebony, and other woods formed into a paste with blood and pressed into moulds or dies. The furrier finds a use for the sawdust of mahogany and rosewood in dressing his furs, and the small fragments of some woods, such as the pencil cedar, made by saw cuts or the turning tool, yield perfumes. Sawdust sinks in water although the wood from which it is cut floats.

Scythians, a nomad race of Asia known to the

ancient writers. The name bore two significations, meaning (1) the Scythians proper or Scolots, (2) all the nomad tribes (Sace, Sarmatians, Massagete, Scolots) who dwelt in the steppes from what is now Hungary to the mountains of Turkestan. Some modern authorities believe them (the Scythians proper) to have been of Mongolian origin; but the evidence for their having been Aryans, akin to the Sarmatians and to the Thracians, is growing steadily stronger. They inhabited the vast treeless plains that stretch from the Danube north-east and east to the Volga, were nomads, keeping herds of horses, cattle, and sheep, lived in tent-covered wagons, fought with bows and arrows on horseback, made drinking-skulls of the heads of their slain enemies, were filthy in their habits, never washing, and worshipped without images various gods like those of the Aryan Greeks. From the Greek colonies established north of the Euxine they learned something of the arts of civilisation; one of their kings, Anacharsis (q.v.), even went to Athens to learn at the feet of Solon. In the 7th century B.C. the Scythians (i.e. some of the nomad races of the steppes) invaded Media, and were only got rid of after ten years' occupation by Cyaxares making all their chiefs drunk at a banquet, and then slaying them. About the same period (626) certain fair-haired men from the north invaded Palestine and Egypt; these have been identified with the Scythians, and were the same, in all probability, as the riders and bowmen of whom the prophet Jeremiah speaks (chap. iv.-vi.). In 515 Darius crossed the Hellespont and went north over the Danube into the country of the Scythians (Scolots); but the difficulties and dangers of the wholly unknown country compelled him to retreat, suffering heavy losses. Shortly after the middle of the 4th century the Scythians (Scolots) in Europe were subdued and in great part exterminated by the Sarmatians. The Scythians of Asia, however, after about 128 B.C. overran Parthia (Persia), routed several Parthian armies, and levied tribute from the Parthian kings. They founded also in the east of the empire the kingdom of Sacastane, so that that part of Asia was long known as Indo-Scythia. During the first century before and the first century after Christ hordes of Scythians, having overthrown the Bactrian and Indo-Greek dynasties of Afghanistan and India (125-25 B.C.), invaded Northern India; and there they maintained themselves with varying fortune for five centuries longer. Their kings were warm supporters of northern Buddhism; indeed an attempt has been made to show that Buddha was of Scythian descent. The Jats of India, and the Rajputs, have both been assigned the same ancestry. Greek influence told strongly on the Scythian conquerors: Greek was even used as the official language of several dynasties in Bactria and the Punjab.

Sealing-wax. Before the composition of ordinary sealing-wax was known in Europe coloured beeswax was used for sealing letters and for attaching the impressions of seals to documents. Sealing-wax with Lac (q.v.) as the principal ingredient was probably first made in India or China, since it is only in these and neighbouring countries that the lac insect is found. Beckmann states that the use of sealing-wax made of lac was apparently very common among the Portuguese about the middle of the 16th century. The best red sealing-wax consists of shellac from 5 to 6 parts, Venice turpentine 3 to 4 parts, vermilion 3 to 4 parts, to which is frequently added $1\frac{1}{2}$ part of magnesia, chalk, or gypsum, or a mixture of some of these. Inferior but still fairly good kinds have a considerably less amount of shellac and vermilion in their composition. Parcel-wax is made of shellac 3 parts, common resin 7 parts, turpentine $5\frac{1}{2}$ parts, chalk and gypsum together $3\frac{1}{2}$ parts, and either vermilion 3 parts, or red-lead 6 parts. Bottle-wax is often made of pine-resin, turpentine, chalk, and some colouring matter; but it is very brittle unless about 10 per cent. of shellac is added.

In making sealing-wax the shellac and other materials are carefully melted in metal pans, and quickly stirred to prevent heavy colouring matter such as vermilion from falling to the bottom. The melted sealing-wax is then poured into metal moulds to form it into sticks, which are removed when cold. By one method the sticks are polished by spreading them on a table and passing a red-hot bar of iron over them. Another way is to hold them into a stove, and in either case till the surface just begins to melt. Sealing-wax is

made in various colours, the finer qualities, however, being most largely in red. White, until recently, was chiefly coloured by subnitrate of bismuth, but a special kind of white-lead is now employed. Black is made by the addition of lampblack or vine-black to the other materials. For brown, umber is added; for blue, artificial ultramarine or Berlin blue; for green, Berlin blue and chrome-yellow; for yellow, either chrome-yellow (which will not stand a high heat) or ochre. For common wax some cheaper colouring materials are used, such as baryta for a white. Aniline colours have been tried for sealing-wax with some promise of success.

Seidlitz Powders (so named from the village of Seidlitz or Sedlitz in northern Bohemia, where there is a spring of natural aperient mineral-water with similar constituents) are composed of 120 grains of tartrate of soda and potash and 40 grains of bicarbonate of soda reduced to powder, mixed and enclosed in a blue paper, and 38 grains of powdered tartaric acid in a white paper. The contents of the blue paper are dissolved in from half a tumbler to a tumbler of water, and those of the white paper are then stirred in. The mixture should be taken while the effervescence from the liberation of the carbonic acid is still going on. These powders act as an agreeable and mild cooling aperient. If a stronger dose is required, either an increased quantity of the powder may be used, or a little sulphate of magnesia (about a drachm) may be added.

Shell, a hollow projectile containing a bursting charge of gunpowder or other explosive ignited at the required instant by means of either time or percussion fuses (q.v.). Originally shells were made of cast-iron, spherical in form, filled with powder, and fired only from Mortars (q.v.) or Howitzers (q.v.) with time fuses. They were called *Bombs* (q.v.) at first, and afterwards *common shells*. A smaller kind were thrown by hand and called *hand-grenades*. Shells appear to have been first used by the sultan of Gujarat in 1480; they were in general use about the middle of the 17th century.

But the introduction of *Shrapnel* shell (so called from the inventor, Colonel Henry Shrapnel, R.A.; died 1842) during the Peninsular war led to the employment of this projectile first with specially manufactured shell-guns, and then, as at present, with all guns of whatever construction. *Shrapnel* shells have thinner walls than *common*, and, instead of powder, are filled with bullets and a small bursting charge just strong enough to open them without disturbing the flight of the bullets. The latter then spread over a considerable area with the velocity which the shell had at the moment of bursting. These projectiles are generally burst by time fuses at least 100 yards in front of and some 50 feet above the target, so that what is called the *cone of dispersion* of the bullets may be as favourably placed as possible. They are essentially man-killing projectiles, in contradistinction to *common shells*, which are chiefly useful for destroying *matériel*.

The original *Shrapnel* shell was of course spherical for use with smooth-bore guns. It was improved by the introduction of a *diaphragm* to separate the bursting charge from the bullets. When rifled guns and elongated projectiles came into vogue it was found that the ricochet of a solid shot was so erratic that it could not, like the old round shot, have any useful effect, and solid shot gradually ceased to be used, *Shrapnel* and *common shell* and *case-shot* being the artillery projectiles retained.

The *Armstrong Segment* shell (a sort of *Shrapnel*) is filled with iron segments built up inside it instead of bullets. It was found to give poor results owing to the spin of the shell due to the rifling dispersing the segments on bursting. The German and Swiss *Ring shell* is somewhat similar, having rings of iron built up inside it round the bursting charge; but it is a sub-

stitute for common shell, not for *Shrapnel*.

Until quite recently *Shrapnel* shell found no favour with foreign nations, but by 1892 they had all followed the example set by Great Britain in adopting it. Fig. 1 is a section of modern British steel *Shrapnel*, with soft metal driving-band at base to give rotation, instead of the metal studs or lead-coating formerly used for that purpose. The bursting charge is at the base of the fuse-hole, and the head is filled with wood. Fig. 2 is the section of a *common shell*. Shells of all sizes are constructed on the same principles.

Palliser's shells have sharp-pointed heads, no fuse-holes, and very thick walls. They are cast head downwards in thick metal moulds. Their heads are thus chilled, and become hard enough to pierce ship's armour. In passing through the armour the bursting charge is exploded, so that no fuse is needed.

Common shells are now being charged with high explosives in France and Germany. The French use *cresylite*, a compound of cresol as *melinite* is of phenol, each being a product of gas-tar; the Germans use *gun-cotton*. The destructive effect of such bursting charges is of course much more than that of an equal amount of gunpowder. At CANNON will be found more information about Shells, and an illustration of a Whitworth forged shell; see also *CASE-SHOT*, *GRENADE*, *PALLISER*, &c.

Shot is the term applied to all solid projectiles fired from any sort of firearms; those for cannon and machine guns being of cast-iron or steel, those for small-arms of lead. Solid shot of more than 3 lb. weight are no longer used as artillery projectiles except where the armament is obsolete (smooth bore or Armstrong guns). Even the *Palliser* chilled shot for piercing armour is not quite solid, having a small internal cavity. *Bar-shot* were two discs of iron connected by a bar, and used formerly to destroy the rigging and spars of ships. *Chain-shot*, for the same purpose, were two round shot connected by a chain. *Case-shot* (q.v.) or *canister* is used with all guns to ward off a sudden attack, as of cavalry or of boats; it consists of a tin cylinder fitting the bore of the gun, and filled with bullets. *Grape-shot* is obsolete. It consisted of small iron balls (1 lb. to 2 lb. weight) held together on a spindle by canvas or by iron plates so as to be easily inserted in the gun.

Small-shot for sporting purposes is of various sizes, from buck-shot, nearly as large as peas, to dust-shot. It is made by dropping molten lead through a colander in rapid motion from a considerable height into water. The lead falls in small globular drops through holes varying in size according to the denomination of the shot, No. 0 requiring holes $\frac{1}{16}$ th inch in diameter, No. 9, $\frac{1}{32}$ th inch. A small portion of arsenic is melted with the lead to 'harden' it, and the fusion in the colanders is maintained by those vessels being surrounded by burning charcoal. The fall through the air enables the lead to cool and harden before taking its plunge. The smaller sizes require less fall than the larger—100 feet suffices for sizes Nos. 4 to 9; the larger sorts demand 150 feet. The highest shot tower is at Villach in Carinthia, where there is a fall of 249 feet. After cooling, shot is sifted in successive sieves to separate the sizes. Misshapen shot are found by their inability to roll down an inclined plank; and finally the whole are polished by rotary motion in small octagonal boxes, in which a little plumbago has been thrown.

Shoulder-joint, an enarthrodial or ball-and-socket joint. The bones entering into its formation are the humerus or arm-bone (see ARM) and the scapula or shoulder-blade. The former has already been described; the latter is a flat triangular bone which is indirectly attached to the trunk by articulation with the clavicle. When the arm hangs by the side the scapula covers the ribs posteriorly from the second to the seventh or eighth inclusive. It presents a posterior surface or *dorsum*, an anterior surface or *venter*, three borders, three angles, and certain outstanding processes.

The figure represents a posterior view of the scapula. It is divided into two unequal parts, the supra-spinous fossa (1) and the infra-spinous fossa (2), by the spine (10), a crest of bone commencing at a smooth triangular surface (11) on the internal border, and running across towards the upper part of the neck of the scapula (8), after which it alters

its direction, and projects forwards so as to form a lofty arch, known as the acromion process (12), which overhangs the glenoid cavity (6), or receptacle for the head of the humerus. The acromion obviously serves to protect the shoulder-joint, as well as to give great leverage to the deltoid muscle which raises the arm. From the upper part of the neck (8) there proceeds a curved projection termed the coracoid process; it is about 2 inches long, and gives attachments to several muscles. The upper border of the scapula presents a notch (4), which in the recent state is bridged over by a ligament, and gives passage to the supra-scapular nerve.

The large globular head of the humerus is received into the shallow glenoid cavity of the scapula, an arrangement by which extreme freedom of movement is obtained, while the apparent insecurity of the joint is guarded against by the strong ligaments and tendons which surround it, and above by the arched vault formed by the under surface of the acromion process. As in movable joints

generally, the articular surfaces are covered with cartilage, and there is a synovial membrane which lines the interior of the joint. The most important connecting medium between the two bones is the capsular ligament.

The shoulder-joint exhibits the following varieties of motion: (1) flexion, to a great extent; (2) extension, in a much more limited degree; (3) adduction, in an oblique direction, forwards and inwards; (4) abduction very freely; (5) circumduction; and (6) rotation slightly.

The morbid affections of the shoulder-joint may be divided into those arising from disease and those dependent on an accident. The most common diseases are acute and chronic inflammation of the joint, which often terminate in its ankylosis or immobility. The principal accidents are fractures and dislocations. There may be fracture (1) of the acromion process, or (2) of the coracoid process, or (3) of the neck of the humerus lying in the axilla.

the scapula, or (4) of the superior extremity of the humerus; or two or more of these accidents may be associated. Again, the head of the humerus may be dislocated from the glenoid cavity as the result of accident in three different directions—viz. (1) downwards and inwards into the axilla, which is by far the most common form; (2) forwards and inwards; and (3) backwards on the infra-spinous fossa, or the *dorsum* of the scapula. The first of these varieties is of very common occurrence, and everybody should know how to recognise, and even (in an emergency) to treat it. The bones are in

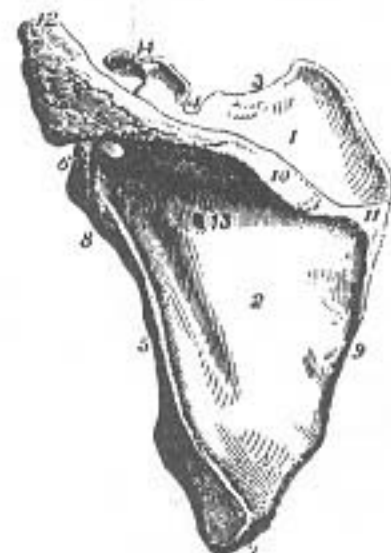


Fig. 1.—Posterior View of the Left Scapula:

The parts designated by the figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 are sufficiently described in the text; 3 is the superior border; 5, the external or axillary border; 7, the inferior angle; 9, the internal or vertebral border; 12, the acromion process; 13, one of the nutrient foramina; 14, the coracoid process.



Fig. 1. Shrapnel Shell.



Fig. 2. Common Shell.

the position shown in the figure; the arm is lengthened; a hollow may be felt under the acromion, where the head of the bone ought to be; the shoulder is flattened; the elbow sticks out from the side, and cannot be made to touch the ribs; and the head of the bone can be felt if the limb be raised, although such an attempt causes great pain and weakness. The methods of treating such a case are discussed at DISLOCATION. The scapula may also be fractured in any of its parts as the result of direct violence, and its inferior angle may slip from its natural position.

Silicon, or **SILICIUM**, is one of the non-metallic elements: sym. Si; at. wt. 28.4 (O = 16); sp. gr. of crystalline form, 2.49. It may be obtained in three different forms—viz. the *amorphous*, the *graphitoid*, and the *crystalline*. It is amorphous silicon which is obtained by the processes in common use, the other forms being obtained from it.

Amorphous silicon presents the appearance of a dull brown powder, which adheres to the finger, is insoluble in water and in nitric and sulphuric acids, but readily soluble in hydrofluoric acid and in a hot solution of potash. It is a non-conductor of electricity, and when heated in air or oxygen its external surface burns brilliantly, and is converted into silica, which fuses from the extreme heat, and forms a coating over the unburned silicon. *Graphitoid* silicon is obtained by exposing the amorphous variety to an intense heat in a closed platinum crucible. This form of silicon will not take fire when heated in oxygen gas, and resists the solvent action of pure hydrofluoric acid, although it rapidly dissolves in a mixture of nitric and hydrofluoric acids; moreover, it is a conductor of electricity. Deville obtained *crystallised* silicon in regular double six-sided pyramids of a dark steel-gray colour.

Silicon, in a state of combination with oxygen, is the most abundant solid constituent of our globe; in less proportion, is an equally necessary ingredient of the vegetable kingdom; while in the animal kingdom it occurs in mere traces, except in a few special cases. It is never found in nature except in combination with oxygen; but, by a somewhat difficult process, it may be separated as a dark brown powder. It was first isolated by Berzelius in 1823. For our knowledge of the other modifications we are indebted to Wöhler and Deville.

Silicon forms two oxides, one of which is only known in the hydrated state, while the other is the well-known compound silica or silicic acid. Silica or silicic acid is represented by the formula SiO_2 , and a hydrate, $3\text{H}_2\text{O} \cdot 2\text{SiO}_2$, has been obtained, while other hydrates are known to exist.

Silica exists both in the crystalline and in the amorphous form. The best examples of the crystalline form are rock-crystal, quartz, chalcedony, flint, sandstone, and quartzose sand. Silica in this form has a specific gravity of about 2.0, and is only attacked with difficulty by potash or hydrofluoric acid. The amorphous form exists naturally in opal, and is obtained artificially as gelatinous silica, &c.; it differs from the former in its specific gravity, being about 2.2, and in its being rapidly dissolved by potash and by hydrofluoric acid. Pure silica (as it occurs in rock-crystal, for example) is perfectly transparent and colourless, and is sufficiently hard to scratch glass. The heat of the oxyhydrogen blowpipe is required for its fusion, when it melts into a transparent glass, capable of being drawn out into elastic threads. Perfectly pure silica in its amorphous form may be obtained by various chemical processes. If a solution of silicate of potash or soda be treated with hydrochloric acid, the silicic acid separates as a hydrate, and on evaporating this to dryness, and treating it with boiling water, silicic acid remains as an amorphous powder, which, after being washed, dried, and exposed to a red heat, may be regarded as chemically pure. The hydrated silicic acid mentioned in the above experiment is soluble in water, and (more freely) in acids and alkalis. The solubility of hydrated silicic acid in water accounts for the presence of silicic acid in mineral springs and in the geysers of Iceland, as well as for its gradual separation from these waters in the form of petrifications. That silica or silicic acid is a true acid (although a feeble one) is obvious from its uniting with bases, especially those which are capable of undergoing fusion, and forming true salts, known as silicates. These silicates occur abundantly in nature, all the forms of clay, felspar, mica, hornblende, augite,

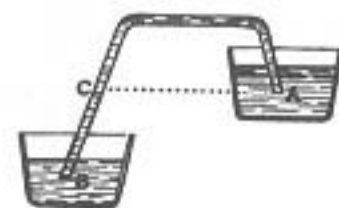
serpentine, &c. being compounds of this description.

Most of the silicates are fusible, the basic silicates fusing more readily than those which are either neutral or contain an excess of acid. Excepting the silicates of the alkalis, no silicates are soluble in water. The anhydrous, neutral, and acid silicates of the earths resist the action of all acids except the hydrofluoric.

Silica derives its name from the Latin *silex*, 'flint,' of which it is the essential constituent, and is largely employed in the manufacture of glass, china, and porcelain. For these purposes it is obtained in a finely comminuted state by heating flints or portions of colourless quartz to redness, and plunging them in cold water. The silica splits up into a friable mass, which may be easily ground to a fine powder. The use of silica in giving firmness and rigidity to various parts of the animal organs is exemplified in its free occurrence in the quill-part of the feathers of birds, in the shields of certain infusoria, and in the spicula occurring in sponges; while its similar use in the vegetable kingdom is seen in its more or less abundant presence in the stalks of the grasses, more particularly in the cereals and in the bamboo (where it is especially deposited about the joints, and is known as *Tabasheer*), in the *Equisetæ*, &c.

Silicon may be made to combine with several other elements besides oxygen, but, with the exception of silicofluoric acid, these compounds are of no practical value. Thus, silicon and hydrogen form a hydride of silicon, a colourless and spontaneously inflammable gas. Nitride of silicon is a bluish fibrous body, while sulphide of silicon is a white earthy powder. Silicon unites with chlorine, bromine, and probably iodine and fluorine, in two proportions corresponding to its oxygen compounds. Fluoride of silicon, SiF_4 , is a colourless pungent gas, liquefiable under strong pressure, and solidifying at -220° , inflammable, and a non-supporter of combustion. It is obtained by heating powdered glass with twelve times its weight of oil of vitriol, and when a stream of this gas is transmitted through water a reaction takes place; two atoms of water and three atoms of the fluoride of silicon yielding silicofluoric acid, H_2SiF_6 , which remains in solution, and silicon, which is deposited. A saturated solution of this acid forms a very sour fuming liquid, which does not directly attack glass, but if allowed to evaporate on it causes erosion from the fluoride of silicon becoming evaporised, and free hydrofluoric acid being left. A dilute solution is sometimes employed in the laboratory as a precipitant of potash, which it throws down in a transparent gelatinous form. With salts of baryta it gives a white crystalline precipitate. It combines with bases to form salts.

Siphon, a bent tube for drawing off liquid from one vessel to another. When in action the tube must be itself full of the liquid, so that the quantities of liquid in the two vessels form one continuous liquid mass. In accordance with the principles of Hydrodynamics (q.v.), there will be, in these circumstances, a flow of liquid along the tube until either the free surfaces of liquid in the two vessels are brought to the same level, or the one vessel or the siphon becomes emptied of liquid. If it is desired merely to empty one vessel, a second vessel is not necessary. The principle on which the siphon acts will be readily seen by consideration of the figure. The two free surfaces are at the atmospheric pressure, but are at different levels. Take C at the same level as A. Then the pressure at A is obviously greater than the atmospheric pressure, while the pressure at C is less than the atmospheric pressure by the amount of pressure due to the column of liquid between C and the free surface in the lower vessel. Hence there must be a flow of liquid from A to C along the tube—i.e. from vessel to vessel. In the upper part of the siphon the liquid is sustained by the pressure of the atmosphere on the free surface, just as in the Barometer (q.v.). If then the siphon reaches higher above the free surface than the height of the barometer column of liquid used, the continuity of liquid will be broken at the bend, and the siphon will cease to act. Thus a siphon for water cannot be higher



than 33 feet above the water surfaces; and a siphon for mercury is similarly limited to 30 inches. To bring it into working condition, a siphon is usually filled by suction applied (either by the mouth or by a pump) at the one end, the other end being immersed in the liquid; or it is first filled with the liquid and then placed in its proper position.

Skin. The skin forms a complete covering for the outer surface of the body, and consists of two distinct layers, of which the outer is termed the *epidermis*, *cuticle*, or *scarf-skin*, and the inner the *corium* or *cutis vera*. Moreover, the skin contains certain structures termed 'tactile corpuscles,' by means of which the properties of bodies are revealed to the sense of touch; and associated with the skin there are such accessory organs as hair, nails, sebaceous glands, and sweat-glands.

The *epidermis* is non-vascular, and forms a protective covering for the *cutis vera*. It varies in thickness from $\frac{1}{16}$ th to $\frac{1}{4}$ th of an inch, being

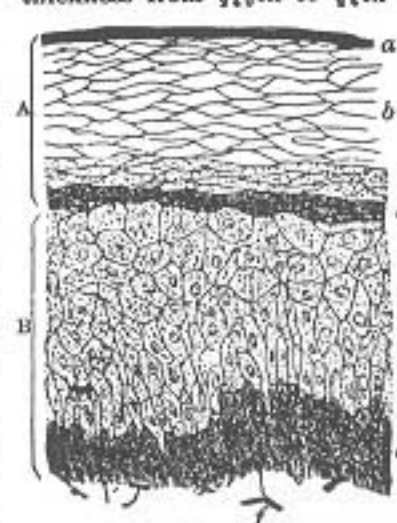


Fig. 1.—Section of Epidermis from the Human Hand, highly magnified (Ranvier):

A, horny layer, consisting of a, superficial horny scales; b, swollen out horny cells; c, stratum lucidum; B, rete mucosum, consisting of d, prickly cells; e, elongated cells near corium; f, a nerve-fibre.

thickest in the palms of the hands and soles of the feet. In structure it consists of cells, closely adherent to each other by their margins, and arranged in many irregular layers. The individual cells vary in shape, being perpendicular in the deepest layer, and passing by various transitions into a surface stratum of hardened flattened cells, which are constantly being thrown off by desquamation; fig. 1 shows the various transitions. In many of the cells, even of white races, pigment granules are found, and these account for the tawny colour of the skin. A section of the epidermis of a Negro's leg, showing the cells of the horny and mucous layers, will be found at Epidermis (q.v.). If a large portion of the epidermis be removed, the process of repair is slow, and proceeds from the edges of the wound, but recovery is quicker if any of the deeper cells of the layer remain. Skin-grafting aims at transplanting small portions of healthy epidermis—including its deeper layers—to denuded surfaces, and when the grafts take root the raw surface is much more speedily covered because the healing process spreads from each graft (see RHINOPLASTIC OPERATIONS). Nails and Hair (q.v.) are growths of the epidermis.

The *cutis vera*, *corium*, or *true skin* is a vascular and sensitive structure, everywhere covered by the epidermis. It rests on a layer which in most places contains fat—the *panniculus adiposus*—and to this layer the corium is sometimes loosely, sometimes firmly, attached. In structure the true skin consists of an interlacing network of white fibrous tissue with a mixture of elastic fibres. On its deep aspect the meshes are more open, and contain lumps of fat. In this way the corium gradually blends with the subcutaneous layer, and so its thickness is not definite, but is generally regarded as varying from $\frac{1}{16}$ th to $\frac{1}{4}$ th of an inch. Wherever hairs occur bundles of muscular fibres are found. The outer surface of the corium is characterised by furrows, which also affect the epidermis. The largest furrows are found opposite the flexures of joints. Finer furrows may be seen on the backs of the hands; while on the skin of the palms and soles ridges with intervening furrows form patterns which are characteristic of each individual. These patterns are permanent, and do not materially change from infancy to adult life (Galton). The latter furrows are due to the fact that the outer surface of the corium is beset with small elevations termed *papillæ* (fig. 2). These are most fully developed where touch is finest, and they fit into corresponding depressions on the under surface of the epidermis. The deeper layers of the corium

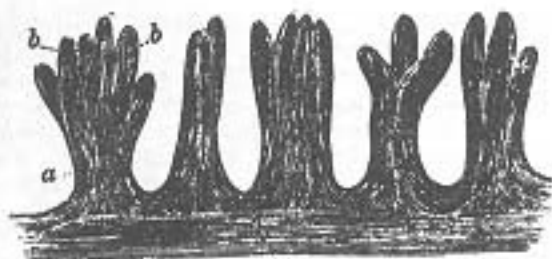


Fig. 2.—Compound Papillæ of Surface of Hand:
a, base of a papilla; b, b, their separate processes. Magnified
60 diameters.

are plentifully supplied with blood-vessels, which form a fine network of capillaries from which loops pass into most of the papillæ. Fine nerves are also supplied to the corium for distribution to the 'touch corpuscles' found in certain papillæ. As a rule papillæ with touch corpuscles have no capillary loop, and thus we distinguish 'vascular' and 'tactile' papillæ. The hair-follicles also receive nerves, and fine varicose nerve-fibrils pass into the deeper layers of the epidermis. *Sebaceous glands*, found wherever hairs are present, pour their secretion into hair-follicles at a short distance from the mouth, unless the hair be small, when the gland may open on the surface of the skin, and the hair project through its duct. Being outgrowths of the hair-follicles they are accessory structures to the epidermis, although the body of the gland is lodged in the corium. They are specially abundant in the scalp and face—some of the largest being found on the side of the nose. Their secretion consists of the fatty degenerated and disintegrated cells which line their interior (see ACNE).

Sweat-glands are found at various depths beneath the corium. Each gland is a coiled-up tube, of which the duct is that part leading in a corkscrew manner through the corium and epidermis to the surface. These glands are also outgrowths of the epidermis, and they are lined by epithelial cells. They are most numerous where there is no hair, but they occur everywhere in connection with the skin. Krause states that 2800 open on a square inch

of skin from the palm; half as many on a similar area on the back of the hand; fewer on the surface of the forehead; 1100 on breast and forearm; while from 400 to 600 are found on the square inch of the lower limbs and back of the trunk. The sweat is naturally alkaline, although it may be found acid owing to the presence of fatty acids derived from the decomposition of sebum. In prolonged sweating the secretion becomes neutral and again alkaline. It is colourless, of a saltish taste, and its odour, which is due to volatile fatty acids, varies with different parts of the body. Coloured sweat is among the phenomena of nervous affections, and instances of blue and bloody sweats are on record. In jaundice the sweat may contain bile-pigment.

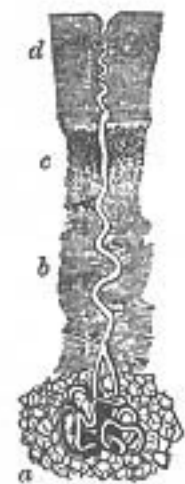


Fig. 3.—Magnified view of a Sweat-gland, with its duct (Wagner):

a, the gland surrounded by fat cells; b, its duct, passing through corium and epidermis.

Ceruminous glands are found in the auditory passage, and have such a close resemblance to sweat-glands that the former may be regarded as modifications of the latter. They yield an adhesive bitter secretion—the wax—which protects the drum of the ear from insects, dust, &c. The most important function of the skin, Touch (q.v.), is separately treated. Regarded as a protective covering, the skin possesses the combined advantages of toughness, resistance, flexibility, and elasticity; the connective framework being the part which mainly confers these properties, although the epidermis co-operates with it. The subcutaneous layer of fat, and the modifications of epidermis in various forms, as hairs, wool, feathers, scales, &c., serve for the preservation of warmth, and occasionally (when they occur as claws, talons, &c.) as means of offence or defence. The skin is the seat of a twofold excretion—viz. of that formed by the sudoriparous glands and that formed by the sebaceous glands. The fluid secreted by the sudoriparous glands is usually formed so gradually that the watery portions of it escape by evaporation as soon as it reaches the surface; but in certain conditions, as during strong

exercise, or when the external heat is excessive, or in certain diseases, or when the evaporation is prevented by the application of a texture impermeable to air, as, for example, oiled silk, or the material known as mackintosh, or india-rubber cloth, the secretion, instead of evaporating, collects on the skin in the form of drops of fluid. When it is stated that the sweat contains urea, lactates, extractive matters, &c., and that the amount of watery vapour exhaled from the skin is, on an average, 2½ lb. daily, the importance of the sudoriparous glands as organs of excretion will be at once manifest. Moreover, there is reason to believe, from the experiments of Scharling, Gerlach, and others, that the importance of the skin as a respiratory organ is far from inconsiderable, very appreciable quantities of carbonic acid being exhaled hourly by the external surface of the body. In the amphibia, in which the skin is thin and moist, the cutaneous respiration is extremely active; and that the respiratory function of the skin in the higher animals is also considerable is proved not only by measuring the excreted carbonic acid, but by the fact that if the skin is covered by an impermeable varnish, or if the body is enclosed, all but the head, in a caoutchouc dress, animals soon die, as if asphyxiated, their heart and lungs being gorged with blood, and their temperature before death gradually falling many degrees.

The skin is, moreover, an organ of absorption: mercurial preparations, when rubbed into the skin, have the same action as when given internally. Thus potassium-tartrate of antimony, rubbed into the skin in the form of ointment or solution, may excite vomiting, or an eruption extending over the whole body. The effect of rubbing is probably to force the particles of the matter into the orifices of the glands, where they are more easily absorbed than they would be through the epidermis. It has been proved by the experiments of Madden, Berthold, and others, that the skin has the power of absorbing water, although to a less extent than occurs in thin-skinned animals, such as frogs and lizards. This fact has a practical application. In severe cases of dysphagia—difficult swallowing—when not even fluids can be taken into the stomach, immersion in a bath of warm water, or of milk and water, may assuage the thirst. Sailors, also, when destitute of fresh water, find their urgent thirst allayed by soaking their clothes in salt water.

Skull. The skull is divided into two parts, the cranium and the face. In human anatomy it is customary to describe the former as consisting of eight and the latter of fourteen bones; the eight cranial bones, which constitute the brain-case, being the *occipital*, two *parietal*, *frontal*, two *temporal*, *sphenoid*, and *ethmoid*; while the fourteen facial bones, which surround the cavities of the mouth and nose and complete the orbits or cavities for the eyes, are the two nasal, two superior maxillary, two lacrimal, two malar, two palate, two inferior turbinated, vomer, and inferior maxillary. The bones of the ear, the teeth, and the Wormian bones are not included in this enumeration. The lower jaw articulates with the temporal bones by means of a diarthrodial Joint (q.v.), but all the others are joined by *sutures*. On the base of the cranium the occipital and sphenoid bones articulate by means of a plate of cartilage (synchondrosis) in young subjects; in adults this becomes bony union. Sutures are named from the bones between which they are found, but to those around the parietal bones special names are given—e.g. *interparietal* or *sagittal*; *occipito-parietal* or *lambdoid*; *fronto-parietal* or *coronal*; *parieto-temporal* or *squamous*. During adult life many of the sutures close by bony union and disappear, but both the age at which this occurs and the order of its occurrence are subject to variation. Wormian bones are irregular ossifications found in relation to the sutures of cranial bones, but seldom seen in relation to the bones of the face. They are most frequent in relation to the lambdoid suture, and seldom one inch in diameter. The closure of a suture stops the growth of the skull along that line, and in order to compensate for this defect an increase of growth may occur at right angles to the closed suture and thus irregularities of form may result: for example, closure of the sagittal suture stops transverse growth, but the skull continues to grow in the longitudinal and vertical directions, with the result that a boat-shaped cranium is produced—*scaphocephaly*. Irregular forms may be produced artificially by pressure applied early in

life. This is best seen among certain American tribes who compress their children's heads by means of boards and bandages. The bones of the skull are pierced by holes (*foramina*), and similar holes are found in relation to the adjacent margins of bones. Most of these foramina are situated in the base or floor of the skull, and are for the ingress of arteries and the exit of veins and cranial nerves. The largest of these foramina—the *foramen magnum*—is found in the occipital bone. It is situated immediately above the ring of the atlas vertebra, and through it the continuity between the brain and spinal cord is established, and further, it transmits the vertebral arteries which supply blood to the brain. Compared with the skulls of animals, the form of the human skull is modified (1) by the proportionately large size of the brain and the consequent expansion of the bones which surround it; (2) by the smaller size of the face, especially of the jaws, so that the face of man, instead of projecting in front of, is *under* the forepart of the cranium; (3) by the *erect attitude*, which places the base of the skull at a considerable angle with the vertebral column, and, in consequence of a development backwards from its point of articulation with the vertebrae, the skull is nearly balanced on the summit of the vertebral column. Hence the orbits look forwards and the nostrils look downwards. The development of the skull is a subject of great interest, not only in itself, but as throwing light on many points which the study of the adult skull

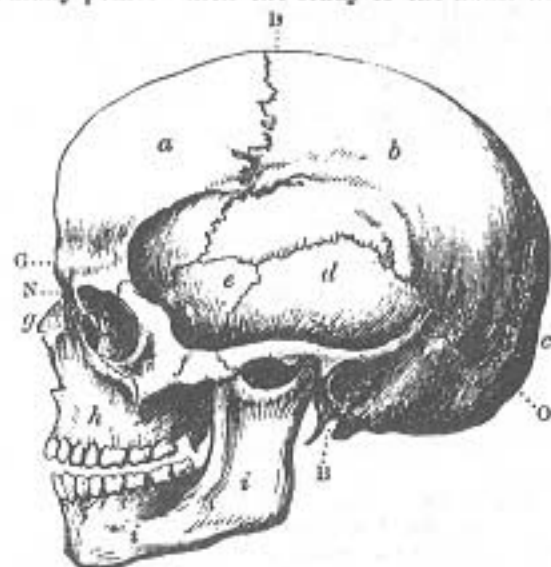


Fig. 1.—Side View of Human Skull:

a, frontal bone; b, parietal bone; c, occipital bone; d, temporal bone (squamous portion); e, sphenoid bone; f, malar bone; g, nasal bone; h, superior maxillary or upper jaw bone; i, inferior maxillary or lower jaw bone; j, inferior turbinated bone; k, vomer; l, inferior maxillary bone; m, teeth; n, ear; o, ear. BD, height of cranium; GO, length of cranium; BN, basibasal length; BA, basibasal length. (These measurements are supposed to be made in a straight line from point to point.)

would fail to explain. At a very early period of foetal existence the cerebrum is enclosed in a membranous capsule external to the dura mater, and in close contact with it. This is the first rudiment of the skull, the cerebral portion of which is consequently formed before there is any indication of a facial part. Soon, however, four or five processes jut from it on either side of the mesial line, which grow downwards, incline towards each other, and unite to form a series of inverted arches, from which the face is ultimately developed. Imperfect development or ossification of these rudimentary parts of the face gives rise to 'hare-lip' and 'cleft-palate,' or in very extreme cases to the monstrosity termed 'Cyclopean,' in which, from absence of the frontal processes, the two orbits form a single cavity, and the eyes are more or less blended in the mesial line.

The cartilage, formed at the base of the membranous capsule, is speedily followed by the deposition of ossific matter at various points of the capsule, which soon becomes converted into flakes of bone; while the intervening portions, which remain membranous, permit the skull to expand as its contents enlarge. Then follows the appearance of osseous nuclei in the cartilage at the base, corresponding to the future occipital and sphenoid bones. Lastly, the various bones, some originating in membrane, and some in cartilage (see OSSIFICATION), approach one another by gradual enlargement, and become united in various ways, so as to form a continuous, and ultimately an unyielding bony case, which is admirably adapted for the defence of the brain, for sheltering the organs of

special sense, and for being attached to the ligaments and muscles by which the skull is supported and moved on the spine. At the period of birth most of the principal bones have grown into apposition with their neighbours, forming the sutures; but one large vacancy remains at the meeting-point of the parietal and frontal bones, which is termed the anterior fontanelle (so called from the pulsations of the brain, which may be here seen resembling the rising of water at a spring or fountain). There are two fontanelles in the mesial line (as shown in fig. 2), and two lateral fontanelles on either side (as shown in fig. 3), which do not close till the second year after birth, and sometimes remains open much longer. The deficiency of the osseous brain-case at this position not only facilitates delivery, but also acts to some extent like a safety-valve during the first months of infantile life, at which time the brain bears an unusually large proportion to the rest of the body,

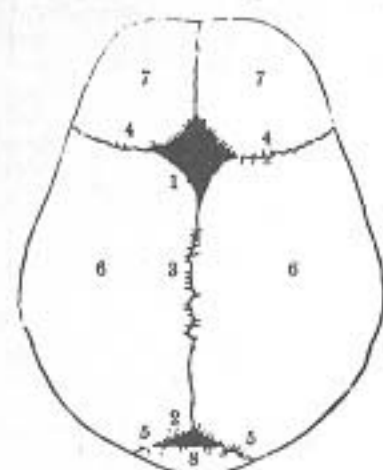


Fig. 2.—Human Skull at Birth, from above:

- 1, anterior fontanelle; 2, posterior fontanelle; 3, sagittal suture; 4, coronal suture; 5, lambdoid suture; 6, parietal bones; 7, two halves of the frontal bone, still united; 8, occipital bone.

and is liable to sudden variations of size from temporary congestion, and other causes. The sutures remain distinct long after the closure of the fontanelles, and serve a purpose both in permitting an increase of the size of the cranium by the growth of the bones at their edges, and in diminishing and dispersing vibrations from blows, and thus contributing to the security of the brain.

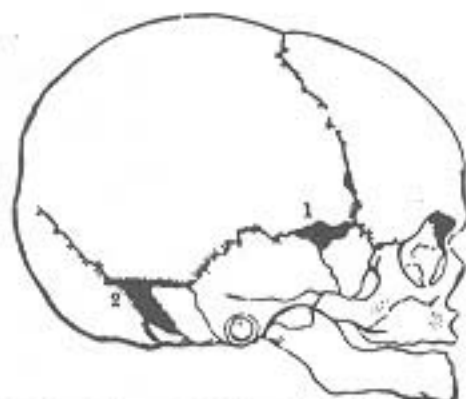


Fig. 3.—Human Skull at Birth (side view):
1, 2, lateral fontanelles.

The number of centres of ossification in the skull is tolerably constant; each bone having a certain number. After the sutures have been formed, and the skull has acquired a certain thickness, a process of resorption commences in the interior of the bones, and reduces the originally dense structure to a more or less cellular or cancellated state. The interior thus altered is called the *Diploë*, and by this change the weight of the skull is much diminished while its strength is scarcely affected.

The *diploë* usually begins to be apparent about the tenth year, and is most developed in those skulls which are thickest. A continuation of the same process of resorption which causes the *diploë* gives rise to the formation of the cavities known as the frontal and sphenoid sinuses. The formation of the *diploë* divides the walls of the cranium into three layers—viz. an outer tough layer; an inner dense, brittle, and somewhat glass-like layer, known as the vitreous table or layer; and the intervening cancellous *diploë*. *Diploë* is absent from the cribriform plate of the ethmoid bone and from the roof of the orbital cavities, and thus these are the thinnest parts of the cranium. The growth of the skull after the seventh year proceeds slowly, but a slight increase goes on to about the age of twenty. The skull-bones are freely supplied with blood from arteries which pass from the dura mater internally

and the pericranium externally, through the numerous foramina observed on both surfaces; the blood being returned by veins which take various directions.

The fact that concussion of the brain scarcely ever proves fatal, unless there is also fracture of the skull, affords the most distinct evidence that the skull is constructed in such a manner that so long as it maintains its integrity it is able to protect its contents from serious lesion. This marvellous protective power is due to its rounded shape, whereby its strength is increased, and in consequence of which blows tend to glide off it without doing material damage. Moreover, the curved lines or ridges which may be traced round the skull tend to strengthen it. The weakest part of the skull is at the base. Hence, notwithstanding

its removal from exposure to direct injury and the protection afforded by the soft parts, fracture takes place more frequently at the base than at any other part of the skull, fracture often taking place here even when the skull was not broken at the part struck. There are two points in the architecture of the bones of the face which deserve especial notice—viz. (1) the great strength of the nasal arch; and (2) the immobility of the upper jaw, which is fixed by three buttresses—the nasal, the zygomatic, and the pterygoid.

The base of the skull, whether seen from within or from below, presents many objects of physiological interest in relation to the nervous system. As seen from within, the base presents on each side three fossæ, corresponding to the anterior and middle lobes of the cerebrum and to the cerebellum. These fossæ are marked, as is the whole skull-cap, by the cerebral convolutions, and they contain numerous 'foramina' and 'fissures' which give passage to various sets of nerves and blood-vessels. The external or outer surface of the base of the skull, if we consider it from before backwards, is formed by the palate processes of the superior maxillary and palate bones; the vomer; the pterygoid and spinous processes of the sphenoid and part of its body; the under surface of the temporal bones; and the occipital bone. The most important of the parts which it presents are named at fig. 4.

The *Morphology of the Skull* is the highest and most difficult problem of comparative anatomy, and has cost the most extraordinary labour for its solution. Goethe and Oken independently suggested that the skull was to be regarded as the modification of a series of four vertebrae, and this 'vertebral theory' was worked out in the most elaborate detail by Owen and other anatomists (see *SKELETON*). Huxley, however, in a celebrated Croonian Lecture (1858), revised and extended the hitherto neglected embryological observations of Rathke, proposed an unanswerable destructive criticism of the archetypal theory, and may be said to have thus definitely placed the newer view in the way of general acceptance. An enormous amount of detailed research, for which we are indebted chiefly to Parker in England and Gegenbaur in Germany, has established the newer theory on the sure ground of actual observation.

Taking first the simple unsegmented cartilaginous cranium of a skate or dog-fish, with its appended jaws and branchial arches, we find that in development, though the notochord extends into the region of the head, the vertebrae stop altogether short

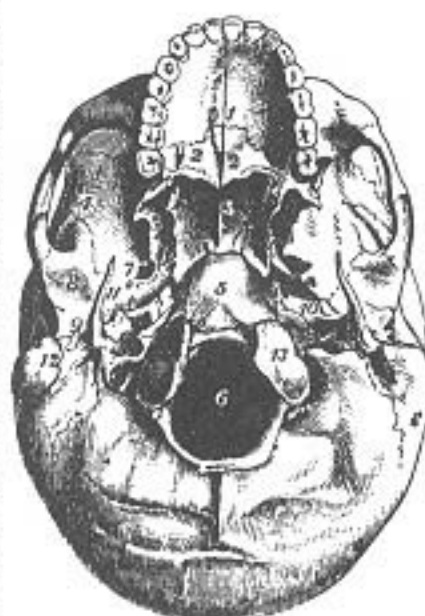


Fig. 4.—Base of the Human Skull:

- 1, 1, hard palate; 2, 2, palate bones; 3, vomer; 4, zygomatic fossa; 5, basilar process of the occipital bone; 6, foramen magnum; 7, foramen ovale; 8, glenoid fossa; 9, external auditory foramen; 10, carotid foramen of the left side; 11, styloid process; 12, mastoid process; 13, one of the condyles of the occipital bone.

of it; but that on each side of the cranium there arise a pair of cartilaginous bars—the *trabeculae* or 'rafters' of the future skull—and three pairs of cartilaginous capsules, nasal, ocular, and auditory, form round the developing sense-organs; the nasal capsules immediately unite with the ends of the trabeculae, which are meanwhile uniting below, and growing up at the sides to form the brain-case. The auditory capsules become united with the trabeculae by the appearance of two new masses of cartilage—the *parachordals*—the eyes of course remaining free. At first there are no jaws, but a series of seven or more similar vertical cartilaginous bars or arches, considerably resembling the trabeculae, between which slits open into the pharyngeal cavity. The first pair of these arches develops an ascending process, which passes above the developing mouth, and becomes the 'palato-ptyergoid' arch or upper jaw, the original portion remaining as the mandible. The second pair of arches—the 'hyoid'—becomes more or less modified usually to aid in supporting the jaws and floor of the mouth, while the remaining pairs become little modified, and serve throughout life to support the gills.

The more complex bony skulls of higher vertebrates are now in principle readily understood. The chondro-cranium and subjacent arches in all cases develop in the same way, although reduction and even atrophy of the gill arches subsequently takes place. The bones, although similar in the adult, originate in two utterly distinct ways, either by actual ossifications in the substance of the chondro-cranium and jaws, or by the ossification of overlying dermis, and are hence known as cartilage bones and membrane bones respectively—the latter corresponding to the dermal bones and teeth of ganoid and elasmobranch fishes. In mammals a further extraordinary specialisation takes place: the ends of the mandibular and hyoid arches lose their suspensory function, are taken up during development into the interior of the ear capsule, and are metamorphosed into the auditory ossicles.

Various Forms of the Skull.—*Age.*—At birth the existence of the fontanelles has already been referred to. The frontal and parietal eminences are especially prominent, and the mastoid process is absent. The face is only one-eighth of the bulk of the cranium, whereas in the adult the face is equal to one-half. During the first seven years the skull grows rapidly, and by this time many parts have attained definite size. At the period of puberty the face and regions of the air-sinuses undergo expansion. The face elongates owing to the growth of teeth and the increase in the size of their alveolar sockets. In old age the skull may become lighter and thinner or the reverse. Loss of the teeth and absorption of their sockets result in diminution of the size of the face, and thus the upper jaw recedes, while the chin becomes prominent.

Sex.—It is not always possible to determine the sex from the skull; but, as a rule, the skull of the male has more strongly marked muscular impressions, while the mastoid processes, superciliary ridges, and air-sinuses are more pronounced than in the female, whose skull generally retains the leading features of a young skull.

Race.—In comparing the skulls of different races of mankind it is necessary to have recourse to various methods of measurement, and these are usually conducted on the skulls of adult males. The following is a short summary of these methods. (a) *Cranial Capacity.*—This is obtained by filling the cranial cavity with shot, and then measuring the quantity in a graduated vessel, special precautions being observed in order to obtain equable results. The capacity of normal human crania

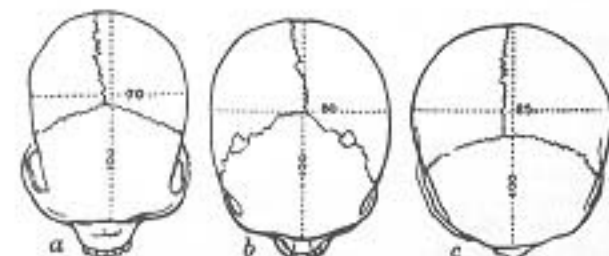


Fig. 5.—Typical Crania seen from the Vertex:
a, Negro, index 70, Dolichocephalic; b, European, index 80, Mesaticephalic; c, Samoyed, index 85, Brachycephalic. (After Tylor.)

varies from 60 to 110 cubic inches—the average in all races being 85 cubic inches—e.g. Eskimo, 91.5;

European, 90.3; Chinese and Mongols, 87.3; African Negroes, 82.4; Native Australians (aboriginal), 79.3; Andaman Islanders, 78.1. (b) Linear measurement of the *horizontal circumference* of the cranium. In the adult European male the average is 20.7 inches, and in the female 19.6 inches. (c) A third method is by comparison of the relative *length, breadth, and height* of the cranium. The standard of maximum length is taken as 100, and thus $\frac{100 \times \text{breadth}}{\text{length}} = \text{index of breadth or cephalic index}$; and on this basis skulls are classified in three groups—viz.:

Brachycephalic = breadth-index above 80.
Mesaticephalic = " " from 75 to 80.
Dolichocephalic = " " below 75.

In a similar way the proportion of height to length may be calculated, and a *height-index* established. It varies less than the breadth-index—e.g.:

	Breadth	Height
Mongolians of Siberia and Central Asia.....	88	73
Andaman Islanders.....	82	77
Chinese.....	79	75
English.....	76	71
Native Australians (aboriginal).....	71	71
Fiji Islanders.....	66	74

(d) *The Degree of Projection of the Jaws.*—We have seen that the human skull, when compared with the skulls of lower animals, presents a small face extended vertically, and thus placed under the anterior part of the cranial box. Prominent jaws therefore indicate an approach to an animal type, especially when associated with a receding forehead. The degree of projection is expressed by

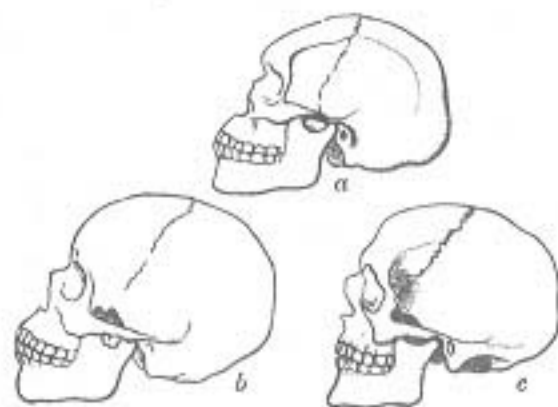


Fig. 6.—Lateral View of three typical Skulls:
a, Australian, prognathous; b, African, mesognathous;
c, European, orthognathous. (After Tylor.)

the *gnathic index* of Flower, and is obtained by comparing the basi-alveolar length with the basi-nasal length. When the gnathic index is below 98, skulls are said to be *orthognathous*; from 98 to 103, *mesognathous*; above 103, *prognathous*—e.g.:

	Gnathic Index
English.....	98
Chinese.....	99
Eskimo.....	101
Fiji Islanders.....	103
Native Australians (aboriginal).....	104

(e) The form of the *nasal skeleton* and its *anterior openings* is also subject to variation, and so its height and width may be measured, and the relation between the two expressed as a *nasal index*.

Nasal index below 48 = leptorhine.
" from 48 to 53 = mesorhine.
" above 53 = platyrhine.

For example:

	Nasal Index
Eskimo.....	44
English.....	46
Chinese.....	50
Native Australians (aboriginal).....	57

In a similar way the form of the orbit is subject to variation, but this is of less consequence than the nose. Other measurements of the face skeleton are also made. A time-honoured measurement, long thought to be sufficient in itself for founding a classification of races, was the *Facial Angle* of the Dutch anatomist Peter Camper (q.v., 1722-89). This was obtained by drawing one line from the centre of the forehead to the most projecting part of the upper jaw just above the incisor teeth, and another from the opening of the ear to the base of the nasal opening; between these was contained the facial angle.

Slags, sometimes called *Scoriae*, are fused compounds of silica with lime, alumina, and other substances. Blast-furnace slag is usually little else than a silicate of lime and alumina. In smelting processes the slag floats on the top of the molten

metal, and is run off or raked off as 'waste material,' provided that the metal has been practically all extracted from it. Many slags which were thrown away in early times have been profitably smelted again in modern days, owing to the amount of metal left in them. Some slags form an opaque glass, but other varieties are more stone-like in appearance, while some are beautifully crystallised. In Great Britain about 18,000,000 tons of iron blast-furnace slag are annually produced. Until comparatively recent times this was considered useless material, but it is now utilised in several ways. By the action of steam upon it in the melted state it is made into fine threads or filaments called 'slag wool' or 'silicate cotton.' This is a bad conductor of heat and sound, and is used as a covering to boilers, and to prevent sound passing through floors. It is also employed for fireproof netting. In some cases blast-furnace slag has been made into serviceable bricks and large blocks for building, as well as into paving setts. On the Continent a useful building cement, or substitute for mortar, has been made from it. The slag from the manufacture of steel from Cleveland pig-iron by the basic process contains about 17 per cent. of phosphoric acid, and forms a valuable fertiliser for sour, peaty, and clay soils.

Sling, a weapon much in use before the introduction of firearms, consisted of a piece of leather, with a round hole in the middle and at each end a cord of about a yard in length. The slinger held the free ends of the cords in one hand, and whirling the weapon round and round with his utmost force in a vertical direction, suddenly let go one of the cords. This propelled the stone or other missile that was placed in the leather at a great speed forwards for a considerable distance. Slings fastened to the end of a short pole were capable of discharging a bolt with such force that at 500 yards distance it could pierce a helmet or a thin shield. The sling is not mentioned in the *Iliad*, but already in the Persian wars we find traces of its use. The Achæmians, and later the Achæmians were the most skilful, but amongst all ancient races the Balearic islanders were counted the most expert; and the sling was a favourite weapon of several semi-savage peoples, notably the Tahitians in the Pacific.

Slow-match, generally rope steeped in a solution of saltpetre and lime-water, and burning at the rate of one foot per hour. Port-fires are very similar, but burn an inch a minute. They were used for firing guns before the introduction of friction tubes, and sometimes for firing military mines, &c. They have been superseded by *Bickford's fuse*, a train of gunpowder enclosed in two coatings of jute thread waterproofed. There are two kinds, the *ordinary* (a slow match), burning at the rate of 3 or 4 inches a minute, and the *instantaneous* (a quick match), burning at the rate of 30 yards per second, and distinguished from the former by yellow threads crossed on the outside.

Soap is the term applied to that class of compounds formed when alkalies act upon fats or fatty acids. Chemically it includes also the insoluble compounds formed from metallic oxides, as lime, litharge, &c.; but industrially it is confined to the compounds of soda and potash. Soap is first mentioned by Pliny, who states that it was prepared from goat's tallow and beech-tree ashes, and was employed for giving brilliance to the hair. The excavations at Pompeii brought to light a complete soap-making establishment, containing some well-preserved soap. The industry, however, advanced very slowly, and it is only within comparatively recent years that it has really flourished. The most important discoveries which have assisted its development and led to its present enormous proportions are Chevreul's researches on the constitution of fats and Leblanc's process for the manufacture of soda on a large scale. It has also been stimulated in Britain by the repeal in 1853 of the duty (amounting to from 1d. to 3d. per lb.), first imposed in 1711. Chevreul showed that the neutral fats are mixtures of 'glycerides,' consisting of glycerine combined with the elements of certain fatty acids. In the process of saponification the fat is decomposed, the fatty acids combining with the alkali to form soap, while the glycerine is set free.

Soaps are distinguished as 'hard' (soda-soaps) and 'soft' (potash-soaps). They have a characteristic taste, and are soluble in water and in alcohol. When agitated with water a 'lather' is

produced, and when their hot aqueous solutions are allowed to cool jellies are formed. Salt precipitates them from their solutions, but in the case of a potash-soap the bulk is converted into a soda-soap by double decomposition. The cleansing power of soap has not been satisfactorily explained; it is generally supposed to be due to the 'hydrolysis,' or partial decomposition into free alkali and insoluble acid-soap which takes place when the soap is dissolved in water. Dittmar considers that the cleansing power of soap may be attributed to 'the inherent property of its solution to emulsify fats,' which seems a more plausible theory.

The principal fats and oils employed in the manufacture of soap are tallow, greases, palm-oil, lard, cocoa-nut oil, and olive-oil for 'hard' soaps; distilled fatty acids are also used, and rosin in conjunction with tallow, &c. For 'soft' soaps linseed-oil, castor-oil, and fish-oils are used, as well as some of those already mentioned. The caustic alkalies, potash and soda, were formerly prepared

from the carbonates by the soap-maker himself, but are now almost entirely procured from the soda-manufacturer.

The following processes, arranged in order of simplicity, are those used in the manufacture.

(1) The direct union of free fatty or resinous acids and alkalies.—This process is seldom used. The fatty acid (e.g. oleic) is run into a steam-jacketed pan, provided with a mechanical agitator, and raised to about 300° F. by super-heated steam. A strong solution of the necessary quantity of alkali is then added, and the whole well stirred. The mixture is allowed to stand for some time, some water added, again stirred, and removed to cooling-frames.

(2) Treatment of fats with definite quantities of alkali, the glycerine remaining with the soap; known as the 'cold process.'—Given weights of fat are melted at the lowest possible temperature, and mechanically mixed in a pan with a definite quantity of caustic lye of known strength, just sufficient to effect complete saponification. After standing for from one to four days, according to the quantity, the soap is hard enough for use. This process possesses the advantages of economy and retention of the glycerine. Soaps made in this way, however, are liable to contain free alkali, and of necessity contain also the impurities of the soda.

(3) Treatment of fats by boiling with indefinite quantities of alkaline lye.—This process is the most important of the three, and will now be described as it is carried out for 'hard soaps.'

Hard Soaps constitute the great bulk of the soaps used, and may be divided into three varieties—curd, mottled, and yellow. The general method is the same for the three. The vessel used (called the 'copper') is made of wrought-iron plates riveted together, and is provided with coils for supplying open and close steam. These 'coppers' are generally of circular form, and capable of turning out from 20 to 30 tons of soap at one operation, although some of them are much larger. In the first stage (called 'killing the goods') a quantity of the fat is melted in the 'copper,' weak caustic lye added, and the steam turned on. The mass becomes pasty after some time, and the boiling is continued, and fat and lye added, until a sample appears somewhat firm, and has very little or no caustic taste. In the second stage ('cutting the soap' or 'salting') the water is separated from the soap (the boiling being continued) by the cautious addition of common salt, or strong brine, until clear liquor runs from a small sample taken out. After standing for a few hours the 'spent lye' (containing the bulk of the glycerine of the fat, common salt, and the impurities of the caustic soda) is removed. In the third operation ('clear boiling') the granulated soap is boiled for two to three hours with fresh lye, in order to cause more complete saponification, and to remove the brine retained by the soap. After settling, the lye is removed, and may be used for the treatment of more fresh fat. The contents of the 'copper' are again boiled with open steam and lye for several hours, to complete the saponification of the last traces of fat, and 'make' the soap.

The method of finishing the soap varies with the kind of soap required, and will now be explained under the names of the three varieties.

Curd Soaps.—The finest quality is made from tallow, but other fats may be used. When the soap has been 'made,' as just explained, the lye is concentrated by means of close steam, until a

sample of the soap appears hard. The boiling is then stopped, and the soap removed, after settling.

Mottled Soaps, as far as composition is concerned, are practically 'curd' soaps; darker fats, however, are used in their manufacture, and after the soaps have been 'made' the lye is not concentrated so far as with 'curd' soaps. Many precautions require to be observed in order to obtain the natural 'mottling' which characterises them. It is due to the presence of small quantities of lime, magnesia, &c., from the materials used, and to oxide of iron, from the 'copper.' These oxides form insoluble soaps, and when the soap, retaining a little lye, is transferred to the cooling frames, they collect together, producing the well-known appearance.

Natural 'mottling' may be accepted as a guarantee of the absence of an undue amount of water in a soap. Artificial 'mottling' of inferior qualities of soap with ultramarine, oxide of iron, &c. is largely practised, sometimes with fraudulent intentions. 'Mottled' soaps are much used for laundry work and such purposes.

Yellow Soaps contain rosin as an essential constituent. The finest qualities are made from the best tallow and light-coloured rosin; inferior qualities from darker tallow, bleached palm-oil, &c., and darker rosin. The rosin is usually introduced after the second stage of the general process. The finishing operation, or 'fitting' of yellow soaps, requires much experience. After the soap has been 'made' the 'copper' is allowed to stand for about twelve hours, the lye removed, and the soap well boiled until homogeneous, with some fresh lye if necessary. When a sample has been found to be in the proper state, the 'copper' is covered up, and allowed to stand for some days, when a separation into three layers takes place—the scum or 'fob' on the top, the 'nigre' (or dark alkaline soap-lye) underneath, and the finished or 'neat' soap in the centre, which is then removed to frames. The 'nigres' are utilised in the making of darker soaps. The principal soap-manufacturers now recover the glycerine from their 'spent lyes.'

Cocoa-nut or Marine Soap.—Cocoa-nut oil is saponified in the heat, with strong lye, without salting out, &c. A hard soap is formed, although much water may be present, and is serviceable on board ship, when condensed water is not available, on account of its solubility in salt water.

The operations subsequent to the soap leaving the 'copper' require little explanation. When no 'filling' substances are to be added the melted soap is run, or ladled, into large oblong boxes of wood or iron, called 'cooling frames.' After standing for several days to allow the soap to harden, the sides of the frames are removed, and the blocks of soap cut, first into slabs, by means of a thin steel wire, and then into 'bars' by a special machine, consisting generally of a strong frame or lever, carrying a number of wires stretched across it. The 'bars,' after having been stamped with the name of the maker, and the brand of the soap, are ready for being sent out.

The demand of the public for cheap soap has led to what is known as 'filling.' This consists in mechanically mixing with or 'crutching into' the soap, after it leaves the 'copper,' certain substances, added either with the view of increasing the detergent power of the soap, or simply to lessen the cost. Silicate of soda belongs to the first class, and is used with advantage in certain soaps. Such substances, however, as water, talc, clay, chalk, sulphate of baryta, &c. must be looked upon merely as adulterants.

Soft Soaps are really impure solutions of potash-soaps, with glycerine, in caustic lye. They form transparent jellies, and often exhibit, in cold weather, a white graining, or 'figging,' due to alkaline stearates. The oil (e.g. linseed, or any other of those named above) is run into the 'copper,' potash lye added, and the steam turned on. The boiling is continued, latterly by close steam or fire heat, and lye added, until a small sample appears clear on cooling, and no liquid separates from it. When finished the soap is run into barrels or tins.

Toilet Soaps.—The basis or 'stock' of the better qualities is generally good curd or yellow soap, special precautions being taken to ensure absence of free alkali. The finest toilet soaps are now 'milled.' For this purpose the soap is cut into shavings, dried partially, the colouring material and perfumes added, and passed several times between granite rollers, to make it perfectly homo-

geneous. It is then subjected to great pressure, or 'plotted,' to form it into bars, which are afterwards cut, and stamped into tablets. The lower qualities of toilet soaps are generally made by the 'cold process.'

'Transparent' soaps are prepared by dissolving good dry soap in alcohol, pouring off the clear solution, and removing the bulk of the spirit by distillation. The remaining soap is transferred to moulds, allowed to cool, and preserved in warm chambers for several months, until it becomes quite transparent. Many transparent soaps, however, are made by the 'cold process,' their transparency being obtained by the addition of sugar. Glycerine is often added to both opaque and transparent soaps, imparting to them its characteristic emollient properties, while such substances as carbolic acid, coal-tar, eucalyptus-oil, &c. are added to soaps intended for disinfecting purposes.

The following table gives the average composition of some genuine soaps of English make:

	Fatty Anhyd.	Alkali (Na ₂ O).	Water.	Salts.	Glycerine and Salts.
Curd.....	63.21	8.44	26.76	1.59	..
Mottled...	64.17	7.90	25.66	2.37	..
Yellow					
(best).....	61.95	7.07	30.45	0.53	..
Cocoa-nut..	52.65	8.55	30.08	..	8.77
Toilet					
('milled')	80.06	9.56	9.11	1.27	..
Soft.....	40.36	9.18	44.78	..	5.68

The commercial value of a soap depends upon its percentage of fatty anhydride. Soap is used otherwise than as a detergent—as a handy ointment for skin irritated by friction, as a laxative medicine, in making pills, liniments, and plasters, and as a test for the hardness of Water (q.v.).

See R. S. Cristiani, *Technical Treatise on Soap and Candles* (1881); W. L. Carpenter, *Soap, Candles, Lubricants, and Glycerine* (1885); A. Watt, *The Art of Soap-making* (1885; 4th ed. 1890); J. Cameron, *Soap and Candles* (Churchill's 'Technological' series, 1888); and C. F. Cross's 'Health Exhibition Lecture on Soap' (1884).

Soapberry. The fruits of several species of trees belonging to the genus *Sapindus* (natural order Sapindaceæ) contain a pulp which is useful as a substitute for soap in cleaning linen and other textile fabrics. In the West Indies the fruit of *Sapindus Saponaria*, and in the East Indies those of *S. emarginatus* and *S. attenuatus* are much used for this purpose. The frothy mixture which these fruits make with hot water is said to be very serviceable for cleaning dyed fabrics which soap would injure. In France silk stuffs are cleaned with the seed vessels of *S. emarginatus*. The seeds of *S. Saponaria* are made up into rosaries, and were formerly worn in England tipped with gold, silver, &c. as buttons.

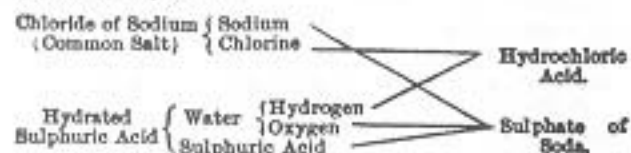
Soda. In its widest sense the manufacture of soda embraces a chain of operations which includes the making of Sulphuric Acid (q.v.), sulphate of soda, Hydrochloric Acid (q.v.), Bleaching Powder (q.v.), caustic-soda, soda-ash (alkali), and crystals of soda (washing-soda). From some of these processes valuable by-products are also obtained, such as iron, copper, and even silver from the pyrites, after the latter is burned to yield the sulphur required to make the sulphuric acid. This sulphur is now recovered on a very large scale from exhausted black-ash by Chance's process.

Formerly most of the soda of commerce was extracted along with other products from the ashes of certain seashore plants (see *BARILLA*, and *KELP*). Natural carbonates of soda (sodium carbonates) are found in different parts of the world, and in some places are worked for use. See *SODIUM*. The quantity of soda obtained from all other sources is, however, now quite insignificant in comparison with that produced by the decomposition of common salt (chloride of sodium). This manufacture occupies the chief place among British chemical industries, and is conducted on a gigantic scale. Two processes are employed for obtaining soda, one of these being known as Leblanc's and the other, which is of comparatively recent date, as the Ammonia-soda process.

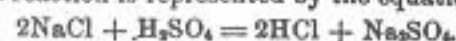
Leblanc's process was first made known to the world by a commission of the French republic in 1794, although dating some years earlier. It has been one of the most valuable discoveries in the

entire range of chemical manufactures, and has been practised for a century without any important alteration. The author of this invention reaped no benefit from it himself, but spent the last of his days in an hospital, 'a wreck in fortune, health, and hope.' Owing partly to the war between France and England, and partly also to the existence of a duty of £30 per ton on common salt, which continued for eight years after the close of the war, Leblanc's process was not adopted in Great Britain except on a very limited scale till 1823. After the repeal of the tax in that year Mr James Muspratt erected his celebrated works at Liverpool, adopted the process in its entirety, and succeeded, after overcoming many difficulties, in establishing this great industry in Great Britain. The object of the process is (1) to convert common salt by the action of sulphuric acid into sulphate of soda (sodium sulphate); (2) to reduce this sulphate to the sulphide of sodium by the abstraction of oxygen; and (3) by certain reactions, in which carbonate of lime (calcium carbonate) takes part, to produce either carbonate of soda (sodium carbonate) or caustic-soda. The several stages are as follows.

Production of Salt-cake or Sulphate of Soda (Sodium Sulphate).—The decomposition of common salt is effected by treating it with sulphuric acid, which converts it into sulphate of soda and hydrochloric acid, thus:



The reaction is represented by the equation



This operation was long conducted in a reverberatory furnace, which allowed the gaseous hydrochloric acid produced to escape into the air, to the destruction of all vegetation in the neighbourhood. Fig. 1 will serve as a diagram to explain the nature of the salt-cake furnace, called a *blind-roaster* or *muffle-furnace*, for making salt-cake. A is the iron pan in which the charge of common salt and sulphuric acid is first placed, and B is the muffle in which the calcination of the half-finished sulphate is completed, the charge being raked from A into B. The fire (C) heating

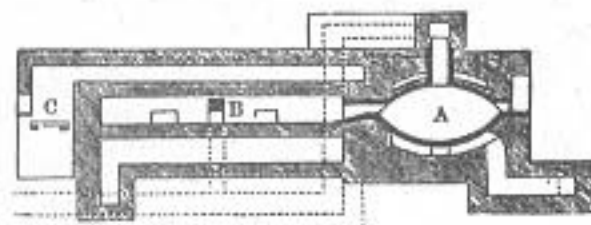


Fig. 1.—Vertical Section of Furnace for making Sulphate of Soda.

the muffle is so placed that the fire gases do not get inside, but heat it by external flues. Usually the pan is heated by a separate fire, but in some instances by the waste heat from the muffle fire. The gaseous hydrochloric acid evolved during the time the reaction between the salt and the sulphuric acid is going on in the pan is sometimes led away to a separate condenser; but if a comparatively pure acid is not required then the gases from both pan and muffle go into the same condenser.

In the case of the *open roaster*, an older kind still used, there is a direct opening from the fire into the bed of the furnace, which is then of an ordinary reverberatory type (see *COPPER*, fig. 1, and *LEAD*, fig. 1), with the pan placed at the end as in the blind-roaster; but in this case the pan has always a separate fire. Coke is generally used for fuel in the open roaster, and with it the pan gas is usually separately condensed. Each of these kinds of furnaces has its advantages and disadvantages. The usual charge for open roasters is about 9 cwt. of common salt, and for close roasters one-half more. With the equivalent quantity of sulphuric acid 100 parts by weight of pure chloride of sodium would theoretically yield

121.45 parts of sulphate of soda, but in practice only about 110 are obtained, owing to the presence of moisture in the common salt. The specific gravity of the sulphuric acid employed varies from 1.700 to 1.720.

Rotating furnaces for making sulphate of soda have been introduced in recent years, the one patented in 1875 by Jones and Walsh being the first which came into actual operation. It has since been improved by the patentees and others, and is now in use at several large alkali-works. Fig. 2 is a diagram of this furnace. It consists of a rotating iron pan, 16 feet and upwards in diameter, placed in a chamber arched over with firebrick. From the fireplace at one side the fire gases pass over the surface of the charge to the flue at the other side. The salt is admitted by hopper closed by a balanced cone, and there are lead-pipes for admitting the sulphuric acid at the edge of the pan. Fixed stirrers or ploughs are used for turning over the charge, which, in the largest sized pans, is now sometimes as much as 25 tons of common salt, and this with 20 tons of sulphuric acid gives 27 tons of sulphate of soda every twelve hours. Gas from a producer is sometimes used to heat the furnace, and a self-acting method of emptying the pan was patented by the inventors in 1880. There is a great saving of manual labour by the use of this furnace. Sulphate of soda, although chiefly consumed as an intermediate product in alkali-making, is used by itself in glass-making, in the manufacture of ultramarine, for cold-producing mixtures, and for making various chemicals.

From any of these salt-cake furnaces the hydrochloric acid gas is led away by pipes or flues to condensing towers sometimes 100 feet high, and filled with pieces of coke. The acid vapour enters at the bottom of the tower, and in ascending through the piled coke meets with a descending stream of water from the cistern on the top by which it is absorbed, and flows away as liquid acid through a pipe at the base of the tower to stock-cisterns. Strong hydrochloric acid, which is chiefly used in the manufacture of Bleaching Powder (q.v.), is easily obtained by good condensing appliances either from the rotatory pan furnace or from the pan of a stationary furnace, but the acid from the roaster gas is usually weak. The Alkali Acts of 1863 and 1874 make the condensation of nearly the whole of the gaseous hydrochloric acid produced at soda-works imperative.

Conversion of the Sulphate of Soda into Black-ash.—The sulphate of soda is roasted with coal and limestone to produce crude carbonate of soda. In this operation the oxygen of the sulphate combines with carbon furnished by the coal to form carbonic oxide, which escapes into the air. The remaining sodium sulphide interchanges combinations with the carbonate of lime (limestone), forming carbonate of soda, easily soluble in water, and calcium sulphide, which is insoluble. The action of the carbon in reducing the sulphate of soda to the sulphide is shown by the equation



The further change which occurs is thus represented:



The proportions of the materials as now used are the same as those first recommended by Leblanc—viz. sulphate of soda, 100 parts; carbonate of lime (limestone), 100 parts; carbon (charcoal), 55 parts. But as coal is employed in England instead of charcoal, the quantity used is generally 75 to 100 of each of the other two ingredients. The 'balling furnace' used in this operation is shown in fig. 3. It has two beds, the one being raised a few inches above the other. F is the fireplace, the waste heat from which is usually employed in boiling down the tank liquor or soda-lye as indicated in the section. The charge of about 8 cwt. of the above mixture is thrown into the bed, A, of the balling furnace, after it has been raised to a bright red heat, and remains till it becomes sufficiently heated throughout the whole mass. It is then transferred to the *fluxing bed*, B, which is next the fire, and exposed to a higher heat, when it shortly begins to soften and flux into a mass like dough. In about fifty minutes the charge is withdrawn in a red-hot state by the working door, and received into iron barrows, where it solidifies into blocks of crude soda, termed ball soda or black-ash.

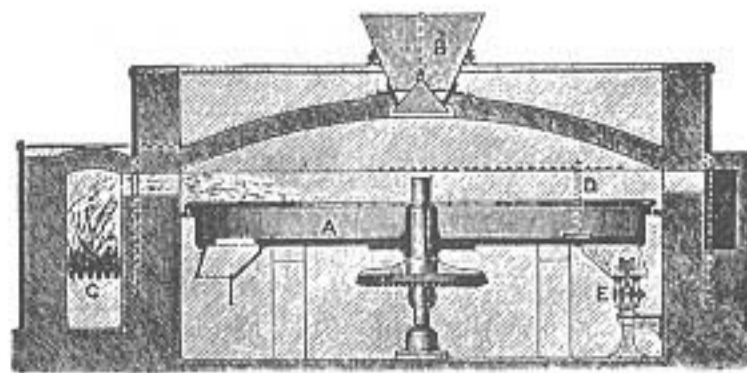


Fig. 2.—Rotating Furnace for making Sulphate of Soda: A, iron pan for containing charge; B, hopper, with balanced cone for charging; C, fireplace; D, one of the stirrers; E, self-acting arrangement for discharging pan.

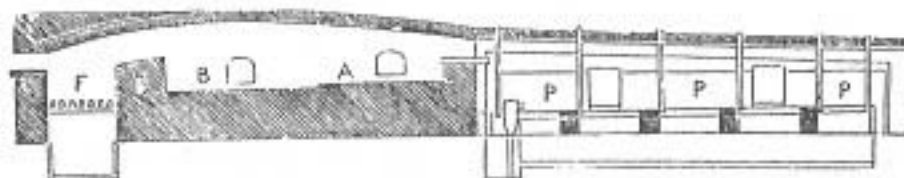


Fig. 3.—Section of Balling Furnace, showing an evaporating pan, P, P, for Soda-liquor in connection with it.

Black-ash is now extensively made in a revolving furnace, which does away with the arduous manual labour required in a stationary furnace, and which was first patented in 1853, though many difficulties had to be overcome before it became a success. Mr J. C. Stevenson, of the Jarrow Chemical Works, after much labour succeeded about 1870 in establishing its superiority over the older kinds of balling furnaces. A longitudinal section of this furnace is shown in fig. 4. It is either cylindrical or barrel-shaped, about 18 feet long and 10 feet in diameter, lined with firebrick. The furnace is driven by steam and the necessary gearing, a spur-wheel being placed round and fixed to the cylinder, which turns on friction rollers. At one end it is furnished with a large fireplace, the fire gases from which pass through the 'barrel,' and onwards to heat the boiling-down pans, which are placed at the opposite end and arranged much in the same way as in the stationary furnace. The larger-sized revolving furnaces produce 30 tons of black-ash in twenty-four hours.

Lixivation of the Black-ash.—The crude soda so named requires to be porous, so that water will easily penetrate the broken lumps of it when placed in iron tanks. Formerly a series, say of four of these, was placed in a step-like arrangement in which the lowest contained the fresh black-ash and the highest that which was nearly exhausted of its soda. Fresh water flowed in at the top, and, as it dissolved out the soda, became gradually stronger in descending from tank to tank, till it reached its full strength in the lowest one. A more recent plan is to have the tanks all on a level and communicating with each other by tubes; but the exhaustion of the black-ash takes place in a similar way. Weak soda liquor is present in the tank with the nearly exhausted ash, and strong liquor in the one containing fresh black-ash, while the other two have liquors of intermediate but unequal strengths. The level of the liquor differs in each, being highest where weakest and lowest where strongest. When communication is opened between these tanks circulation is caused by hydrostatic pressure. The soda liquor from the black-ash is treated differently, according to whether soda-ash or caustic-soda is to be made from it.

Caustic-soda.—As the tank liquor consists of a strong solution of carbonate of soda, it requires to be diluted before it can be causticised with lime. Long iron cylinders contain this diluted liquor, into which lime is placed, and at the same time it is heated and agitated. After being allowed to settle, the clear liquor is drawn off and pumped into liquor settlers, the lime mud in these being saved and used in the black-ash furnace. Several iron concentrating cisterns are successively used with the aid of heat to bring up by degrees the causticised soda liquor to the required strength. From the

last of these cisterns (boat-pans) the liquor, having a specific gravity of 1.550, is run into cast-iron pots, each of a capacity of 10 tons, which are heated by strong fires, and here the concentration of the liquor is completed, and the caustic-soda ladled into sheet-iron 'drums' containing 6 cwt. each. On cooling it solidifies into a white mass of sodium hydrate or caustic-soda, NaOH, which is now manufactured in large quantities, containing as much as 77 per cent. of sodium monoxide, Na₂O. During the concentration nitrate of soda is used to decompose any sodium sulphide present in the liquor. Caustic-soda is most largely used in soap-making and paper-making, but also in the manufacture of some coal-tar dyes and oxalic acid.

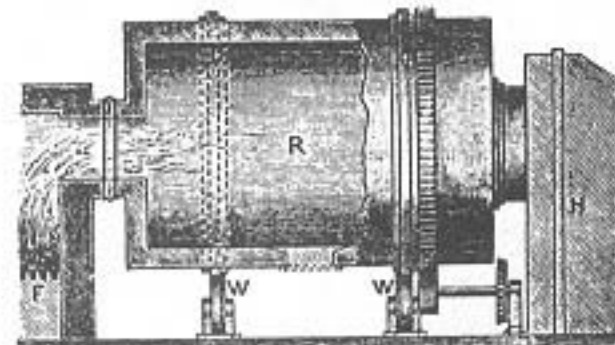


Fig. 4.—Revolving Black-ash Furnace, partly in section: F, fire; R, revolving cylinder; W, friction wheels; H, tanks, &c., for evaporating soda-lye by waste heat of furnace.

Soda-ash.—When this substance (carbonate of soda) and not caustic-soda is to be made, the black-ash liquor is differently treated. In referring to the black-ash furnaces (see figs. 3, 4) it has been stated that their waste heat is used to boil down the black-ash liquor. As the concentration of the liquor proceeds granular crystals of soda are deposited and scraped out into drainers. When heated these crystals yield soda-ash; but impure soda remains in the boiling-down vessel. This soda, which is mostly carbonate but also contains caustic-soda and sodium sulphide, is mixed with some sawdust and evaporated to dryness. The black-salt, as this residual substance is called, is then heated in a carbonating oven in which the burning off of the sawdust generates carbonic acid, and this converts the caustic-soda and sodium sulphide present into carbonate, and soda-ash is the result. The composition of commercial soda-ash is very variable, but it frequently contains about 80 per cent. of the carbonate, the remainder consisting of other compounds of sodium and small quantities of other substances. None of these, however, interfere with its use for the purposes for which it is usually employed. When it is sold the available percentage of soda (sodium oxide or Na₂O) is quoted. For certain purposes soda-ash is refined by dissolving, settling, evaporating, and calcining. It is then called *refined* or *white alkali*, which should be free of caustic-soda and contain no trace of sodium sulphide, sodium sulphite, or of iron.

Crystals of Soda, Washing-soda, $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$.—The soda-ash used for making soda-crystals is previously calcined and dissolved in hot water in iron vessels, the solution being then allowed to cool.

From this solution large crystals of almost pure carbonate of soda separate. Ordinary washing-soda consists of these crystals, which are of uniform composition and easily dissolved. They contain ten molecules of water—that is to say, they are composed of 37 per cent. of carbonate of soda and 63 per cent. of water. Crystal soda being quite free from caustic-soda and other compounds acting on the skin, the hands of washerwomen suffer less from it than from other kinds of alkali.

Bicarbonate of Soda, 2NaHCO_3 .—As will be presently explained, this salt is now prepared on a large scale as a stage in the ammonia-soda process. See SODIUM.

Sulphur Recovery.—The recovery of sulphur from the exhausted black-ash, which forms the waste heaps of the alkali-maker, is now, after many unsuccessful attempts to do so economically, practised on a large scale by Chance's process patented so recently as 1888. This residue, as has been stated, is essentially calcium sulphide, which when brought into contact with carbonic acid in the presence of water is converted into carbonate of lime, and sulphuretted hydrogen is liberated. The practical difficulty had long been the getting of hydrogen sulphide in a sufficiently concentrated state. Mr Chance's process is as follows: The vat mud (black-ash waste) has the coarser extraneous pieces removed by a sifting process, and is then made into a creamy consistency with water. In this state it is distributed into a series of cylindrical iron vessels for the purpose of having carbonic acid passed through it. These cylinders have three main pipes passing over them, with branches to each. By one pipe the carbonic acid is introduced at the bottom of the liquid, and the other two lead the gases away from the top of the cylinder.

The carbonic acid is produced in a limekiln, and passes, unavoidably mixed with nitrogen, into the cylinders, which successively become richer in sulphur compounds. The result is that for a time little else than nitrogen comes away from the last cylinder. But when the reactions in the cylinders are completed the final vessel of the series gives off gas rich in sulphuretted hydrogen. By means of stopcocks one of the pipes at the top of each cylinder conveys the nearly unmixed nitrogen to an open chimney, and the other takes the rich mixture of nitrogen and sulphuretted hydrogen to a gasholder. When the carbonic acid from the limekiln passes into the first cylinder containing the black-ash waste, carbonate of lime is produced with evolution of sulphuretted hydrogen, H_2S . The latter passes on with the excess of nitrogen into the second cylinder, where there is formed sulphhydrate of calcium, CaH_2S_2 , which is a compound of H_2S and CaS . In this way we have the sulphur concentrating from first to last in the series of cylindrical vessels until it is finally expelled as sulphuretted hydrogen gas. In the process the carbonic acid combines with the calcium of the sulphhydrate, giving off the two atoms of sulphur as H_2S , so that for a given amount of carbonic acid used we get a double quantity of sulphur. All the time the vessels at the beginning of the series remain unsaturated, the nitrogen, amounting to about 70 per cent. of the gases pumped in, passes away in pipes, and is allowed to escape. It contains little or no sulphur; but by-and-by the gas in the vessels consists of from 30 to 35 per cent. of sulphuretted hydrogen and from 1 to 2 per cent. of carbonic acid, the remainder being nitrogen. This mixed gas is collected in a gasholder to enable it to be treated as required. The carbonated mud left in the vessels is drained, and used in place of limestone in the black-ash furnaces, so that any soda this dried mud contains is recovered.

The sulphur is obtained from the gas in the gasholder in a very pure state in cakes and flowers of sulphur by this operation. A definite mixture of the sulphuretted hydrogen (present in this gas) and air is passed through a layer of anhydrous oxide of iron in a Claus kiln, the oxygen present being only enough to unite with the hydrogen (of the H_2S) to form water, the sulphur being set free. Iron oxide has the power of producing the combination without itself suffering change, the bed of this material becoming (without the use of fuel) sufficiently hot, by the chemical change which goes on, to volatilise the sulphur vapour along with the steam

produced. The change is represented by the formula $\text{H}_2\text{S} + \text{O} = \text{H}_2\text{O} + \text{S}$. But the sulphuretted hydrogen may also be itself burned to make vitriol, which is obtained of the same purity as when made from sulphur.

The Ammonia-soda process has within the last few years come into competition with and threatens to supersede that of Leblanc. It is based on the mutual reaction which takes place at ordinary temperatures between common salt and bicarbonate of ammonia in strong aqueous solutions. The sodium of the salt combines with the carbonic acid and the chlorine with the ammonia, giving bicarbonate of soda, which is insoluble, and chloride of ammonium, which remains dissolved in the liquid, thus:



The ammonia is recovered from the chloride and one-half of the carbonic acid from the bicarbonate for future use. Where possible natural brine is used, and this is brought to a specific gravity of nearly 1200, either by the addition of salt if too weak or by adding water if too strong. Ammonia in the free gaseous state is now passed into the brine until the required quantity is present, which is known by the amount of increase in the volume of the liquid. The ammonia enters a mixing tank under a perforated diaphragm, and the liquid is kept in agitation. A great rise of temperature is caused by the condensation of the gaseous ammonia, and this necessitates the running of a stream of water through a coil of piping inside the mixer to keep the heat as low as possible. The brine in running off passes through a filter to retain solid impurities, and then through another worm of piping surrounded by cold water. To form the bicarbonate of soda the ammoniacal brine requires to be saturated with carbonic acid. Air-pumps draw the carbonic acid from the limekiln and force it (after being properly cooled) at a pressure of nearly two atmospheres in at the bottom of a tower 50 feet high, which is kept nearly full of the liquid. This tower has perforated plates at every three feet of height to make sure that the gaseous bubbles are spread equally through the liquid. Every half-hour some of the paste mixture in the tower is run off at the bottom. This is full of the small crystals of bicarbonate of soda, and these are separated by running the mass over a wire-gauze filter covered by a cloth, a vacuum being maintained below. The bicarbonate of soda on the filter is nearly pure, and the liquid which passes through is ammonium chloride. The bicarbonate thus obtained is washed with water and carefully dried in apparatus of which there are various forms. As there is a comparatively limited demand for this kind of soda, it is afterwards heated in close vessels in which half of its carbonic acid is given off, thereby reducing it to the normal or common carbonate of soda (soda-ash). The gas given off is pumped back to the tower and used along with the kiln gas for carbonating fresh material. To expel any ammoniacal salts adhering to the carbonate of soda and render it denser for packing, the heat is continued until fusion takes place. The ammonia is recovered from the liquid filtered from the bicarbonate of soda by heating it with lime. After the ammonia is driven off by heat the remaining liquid is calcium chloride, which is generally run to waste.

Sodium (sym. Na; equiv. 22.99; sp. grav. 0.973) is one of the metals of the alkalis, its oxide being soda. Its properties closely resemble those of the allied metal potassium. It is of a bluish-white colour, is somewhat more volatile than potassium, and further differs from that metal in having a higher fusing-point—about 208° (97°C.), a greater specific gravity, and in not catching fire when dropped in water (unless the water is heated), although, like potassium under similar conditions, it partially decomposes it and liberates hydrogen, and at the same time communicates a strong alkaline reaction to the solution. If, however, a piece of unsized paper is placed on the surface of cold water, and the sodium is placed on the paper, the metal takes fire and burns with a deep yellow flame. Strictly speaking, it is the liberated hydrogen rather than the metal which burns; but a little sodium, volatilised by the heat, burns with the hydrogen. When heated in the air it burns with its characteristic yellow flame, and is converted into soda. When exposed *in vacuo* to a red heat it assumes the

form of vapour, and admits of distillation. Like potassium, it must be kept immersed in naphtha,

so as to exclude the oxidising action of the air. As a reducing agent it is little inferior to potassium; and as its combining power is lower, and it is obtained much more cheaply, it may usually be advantageously substituted for potassium in reducing operations. Sodium does not occur in the metallic form in nature, but its compounds are very widely distributed. It is found by far the most abundantly in the form of chloride of sodium (or common salt), but it likewise occurs as albite or soda-felspar, cryolite (the double fluoride of sodium and aluminium), borax (the baborate of soda), trona (the sesquicarbonate of soda), and Chili saltpetre (nitrate of soda). Duhamel in 1736 discovered that potash and soda (now known to be the oxides of potassium and sodium) were distinct bodies. Sir H. Davy first obtained the metal Sodium in 1807. The symbol of this metal, Na, is the abbreviation of *Natrium*, which is derived from *Natron*, one of the old names of native carbonate of soda.

The methods of obtaining sodium are similar to those already described for obtaining potassium. Intimately mix 30 parts of common soda-ash with 13 parts of small coal and 3 parts of chalk, knead them into a stiff paste with oil, heat them in a covered iron pot till the oil is decomposed, and finally distil them in an iron retort with the precautions which are noticed in describing the preparation of potassium. The object of adding the chalk is to prevent the separation of the charcoal from the carbonate of soda when the latter fuses. This mixture ought to yield nearly one-seventh of its weight of sodium.

Sodium combines with all the elementary gaseous bodies, and two of these combinations, those with oxygen and chlorine, are of extreme importance and value. With oxygen sodium forms two compounds—an oxide, Na_2O , and a peroxide, Na_2O_2 . The latter is of no practical value. The oxide (soda) was formerly known as *fossil* or *mineral alkali*, to distinguish it from potash, which, from the source from which it was procured, was termed *vegetable alkali*. Anhydrous soda, Na_2O , is procured by burning the metal in dry air; it is of a yellowish-white colour, powerfully attracts moisture, and retains the water so firmly that it cannot be expelled by heat. Hydrated or caustic soda, NaHO , closely resembles, both in its properties and in the mode of procuring it, the corresponding potash compound. It is, however, not so fusible as the latter, and is gradually converted, by exposure to the air, into carbonate of soda, which is also an infusible salt in its anhydrous state. Solution of hydrate of soda (or soda lye) is largely employed in the arts. It is prepared by boiling a tolerably strong solution of carbonate of soda in milk of lime until a portion of the filtrate ceases to effervesce on the addition of an acid. The solid hydrate has a specific gravity of 2.13, and the quantity of anhydrous soda in any solution may be closely approximated to by determining the specific gravity of the fluid and referring to a table indicating the strength corresponding to the specific gravity.

Many of the combinations of the oxide of sodium (soda) with acids—constituting soda-salts—are of great importance. Carbonic acid forms three salts with soda—a normal carbonate, a sesquicarbonate, and a bicarbonate of soda.

Carbonate of Soda, $\text{Na}_2\text{CO}_3 + 10\text{H}_2\text{O}$, the Soda of commerce, is a colourless, inodorous salt, with a nauseous alkaline taste. It crystallises in large transparent rhomboidal prisms, which contain nearly 63 per cent. of water, but it readily parts with all this water on the application of heat. The crystals also lose the greater part of their water on mere exposure to the air, when they effloresce, and fall to powder. Water at 60° (15°C.) dissolves half its weight of the crystals, and boiling water considerably more, the solution acting like an alkali on vegetable colours. This salt, the *natron* of commerce, occurs native in the natron-lakes of Hungary, Armenia, &c., in association with sulphate of soda and chloride of sodium. In other regions it appears in an efflorescent form on the surface of the earth. It is now, however, almost entirely manufactured from sea-salt. For its manufacture, see SODA.

Sesquicarbonate of Soda, $\text{Na}_2\text{CO}_3 + 2\text{NaHCO}_3 + 3\text{H}_2\text{O}$, occurs native in the form of large, hard, non-efflorescent prisms, in Hungary, Egypt, Mexico, &c., under the name of *Trona*. When strongly

heated it loses one-third of its carbonic acid, and becomes converted into the preceding salt.

Bicarbonate of Soda, NaHCO_3 , may be formed by passing a current of carbonic acid through a strong solution of carbonate of soda, till saturation takes place, and allowing the mixture to crystallise; or it may be produced on a large scale by exposing crystals of carbonate of soda to a prolonged current of carbonic acid. Most of the bicarbonate in commerce is now, however, prepared by the ammonia-soda process (see SODA). In this a current of carbonic acid gas is passed through a solution of salt in aqueous ammonia, when chloride of ammonium and bicarbonate of soda are produced. The bicarbonate crystallises in four-sided prisms, which require 10 parts of water at an ordinary temperature for their solution. This salt is used largely in medicine. See AERATED WATERS.

Sulphuric acid forms with soda a normal and an acid sulphate. The normal **Sulphate of Soda**, $\text{Na}_2\text{SO}_4 + 10\text{H}_2\text{O}$, has been already described under its synonym of *Glauber's Salt* (q.v.). The acid salt, or **bisulphate of soda**, NaHSO_4 , is of no special interest.

The **Hypsulphite of Soda**, $\text{Na}_2\text{S}_2\text{O}_5 \cdot 5\text{H}_2\text{O}$, occurs in large colourless, striated, rhombic prisms, of a cooling and sweet taste. When strongly heated in the air it burns with a blue flame. It dissolves readily in water, depositing sulphur if the solution be kept in a closed vessel. It may be obtained by digesting a solution of sulphite of soda with powdered sulphur. The sulphur is gradually dissolved, and forms a colourless solution, which, on evaporation, yields crystals of hypsulphite of soda. This salt is largely employed in photography, and is occasionally prescribed medicinally. Sulphurous acid forms two salts with soda—viz. a sulphite and a bisulphite. The **Sulphite of Soda**, $\text{NaHSO}_3 + 7\text{H}_2\text{O}$, is obtained by passing sulphurous acid over carbonate of soda, dissolving the resulting mass in water, and crystallising; when the salt is obtained in efflorescent oblique prisms, which are soluble in 4 parts of cold water, the solution having a slightly alkaline reaction and a

sulphurous taste. This compound was at one time commercially known as *Antichlore*, and was largely used in paper-manufactories for the purpose of removing the last trace of chlorine from the bleached rag-pulp. The term is now applied only to the hypsulphite, which is both cheaper and more efficacious. The **Bisulphite** is of no importance. **Nitrate of Soda**, NaNO_3 , known also as *Cubic Nitre* or *Chili Saltpetre*, occurs as a natural product on the surface of the soil of certain South American districts. In most of its properties, excepting its crystalline form, and further in its being deliquescent, it resembles nitrate of potash. It is used as a Manure (q.v.). The **Phosphates of Soda** are comparatively numerous. **Hypo-chlorite of Soda**, NaClO , is at present known only in solution, in which it occurs as a yellowish-green fluid, evolving a smell of chlorine; it has strong bleaching power, and when boiled becomes decolorised, and evolves chlorine freely. It is formed by passing a stream of chlorine gas through a solution of carbonate of soda, the resulting solution containing the hypochlorite, together with undecomposed carbonate of soda and chloride of sodium. This solution is useful as a bleaching agent, as an oxidising agent in analytical chemistry, and as a disinfectant agent. There are two **Borates of Soda**, of which the only important one, the **Biborate**, is already described under its ordinary name of *Borax* (q.v.). Various **Silicates of Soda** have been formed (see SILICON, GLASS, SLAGS).

The **Haloid Salts** of sodium resemble, in their general characters, the corresponding salts of potash. Of these by far the most important is **Chloride of Sodium** or **Common Salt**, formerly known as *Muriate of Soda*, NaCl . It occurs naturally in far greater quantity than any other soluble salt, and is fully described at SALT. The other haloid salts—the iodide, bromide, and fluoride of sodium—require no notice.

Sodium has been recently found to enter into various groups of organic bodies—the sodium-alcohols for example. When sodium or potassium is gradually added to anhydrous alcohol the temperature rapidly rises, the metal is dissolved, hydrogen is evolved, and a fusible deliquescent compound is formed, which has received the name of **Sodium-alcohol** (or potassium-alcohol), or of *ethylate of soda* (or potash), its composition being such that it may be regarded as alcohol in which one atom of hydrogen is replaced by one of the metal.

The tests for the salts of sodium are not very satisfactory, because the metal forms scarcely any insoluble compounds. A salt of sodium is usually concluded to be present when, the absence of all other bases having been proved, a saline residue remains, which, with bichloride of platinum, yields yellow striated prisms by spontaneous evaporation. Before the blowpipe the salts of sodium are known by the intense yellow which they communicate to the outer flame, and if a weak alcoholic solution of one of the salts is burned a similar yellow tint is communicated to the flame. Spectrum analysis is too delicate to be of much practical use.

The medicinal uses of the sodium compounds may be considered alphabetically. **Acetate of Soda** is a mild diuretic, similar in operation to acetate of potash, for which it may be substituted. **Arseniate of Soda** is serviceable in periodic affections, chronic skin diseases, and the cases in which arsenic is generally employed in medicine. Paper impregnated with a solution of arseniate of soda sweetened with sugar is sold as a poison for flies. **Biborate of Soda**, or *Borax*, is employed principally as a topical astringent, and is used with advantage in aphthous eruptions of the mouth and throat. **Bicarbonate of Soda** is a most popular remedy in cases of dyspepsia, but its use is highly injurious when there are phosphatic deposits in the urine. **Carbonate of Soda** is not employed as an antacid so frequently as the bicarbonate, in consequence of its disagreeable taste; but in the dried state, when deprived by heat of its water of crystallisation, it is much used as an alternative. In dyspepsia attended with acidity a combination of the dried carbonate with blue pill and rhubarb pill is often extremely useful. As it has a very acrid taste, it should be combined, if given in powder, with some bland substance, such as Compound Tragacanth Powder. A solution of **Chlorinated Soda** is preferable to hypochlorite of lime in destroying noxious effluvia, as the salt which is left does not deliquesce. **Phosphate of Soda**, known also as *Tasteless Purgine Salt*, is a mild saline purgative, with a far less unpleasant taste than sulphate of magnesia. **Sulphate of Soda** and **Tartrate of Soda** and **Potash** have been already described under their ordinary names of *Glauber's Salt* (q.v.) and *Rochelle Salt* (q.v.).

Specific Density, the mass of any given substance contained in unit volume. On the centimetre-gramme-second system of physical units, since a cubic centimetre of water at standard temperature and pressure weighs 1 gramme, the density of water = 1, and water is the standard of density; and the specific density of a body is the number of grammes' mass per cubic centimetre. Since, according to the law of gravity, weights are proportional to masses, it is convenient to ascertain specific densities by ascertaining the specific gravities of the substances tested. For example, an English gallon of water weighs at standard temperature and pressure (62° F. and barometer 30 inches) 10 lb. avoirdupois; a gallon of ether weighs 7.2 lb.; the specific density of ether is therefore $7.2 \div 10 = 0.72$. Similarly, a gallon of strong sulphuric acid weighs 18.4 lb., and the specific density of sulphuric acid is 1.84. The specific densities of solids may be determined by the hydrostatic balance (see ARCHIMEDES, PRINCIPLE OF), which gives the weight of a quantity of water equal to that of the solid; or by using a 'specific gravity flask.' This is a flask marked distinctively at a certain level; the solid is put into this; the flask is filled with water up to the mark, and weighed; the whole is then emptied and filled with water alone up to the mark, and again weighed. The two weighings give the data for ascertaining the ratio between the weight of the solid and that of an equal bulk of water. If the solid is acted upon by water, some other liquid of known specific density must be employed, and the calculation varied accordingly. If it be lighter than water, it is coupled with a piece of heavy substance whose weight and specific density are separately known, and the aggregate apparent loss of weight incurred by the combination on being immersed in liquid is found by the hydrostatic balance. Of this aggregate so much is due to the heavy substance and the remainder to the light solid. This gives data for calculating the specific density of the light solid. The specific density of a liquid is ascertained by simply comparing the weights of quantities of that liquid and of water successively made to fill the specific gravity flask

up to the same marked level; or by comparing the apparent losses of weight incurred by a solid on being immersed in water and in the liquid respectively; or by the use of hydrometers or areometers. The areometer (*araiaos*, 'thin,' and *metreōs*, 'I measure'; Fr. *aréomètre* or *pèse-liqueur*; Ger. *Aräometer* or *Senkwage*) or hydrometer is a graduated instrument which floats in a liquid, without being wholly submerged, under the equilibrium of the weight of the whole body acting downwards, and the buoyancy of the liquid, equal to the weight of the part of the liquid displaced, and acting upwards. The specific density of a uniform cylinder, say of ice, floating vertically in water is the volume immersed $\div$ the whole volume; and in liquids of different specific densities such cylinders would sink to different depths. But it is more convenient to use graduated hollow glass instruments weighted with mercury at one end to make them float vertically (see fig. 1). AB is graduated; C is a large bulb; D is a small bulb containing mercury, the quantity of which is so adjusted that the instrument sinks in water, say to the point W. If the liquid be heavier than water the instrument will not sink so far; the position of equilibrium in which the weight of the whole instrument is equal to the weight of the liquid displaced will be sooner reached; and, conversely, if the liquid be lighter than water the instrument will sink farther. Each instrument must be experimentally graduated by placing it in liquids of known specific densities. By varying the adjustment of the mercury a series of instruments may be made, serviceable in ascertaining the specific densities of liquids within particular ranges of density—e.g. instruments for sulphuric acid, milk, alcohol, &c. The delicacy of such an instrument depends on the bulb C being large and the stem AB thin. The chief modes of graduation are (1) Gay-Lussac's areometer or volumometer. In water the instrument

Fig. 1. stands at 100°. All the degrees are equal, and each = $\frac{1}{100}$ the volume of that part of the instrument which is immersed when it floats in water. If n be the numerical reading when the instrument is floated in a given liquid, the specific density of that liquid is $100 \div n$ —e.g. if the instrument stand at 80°, the specific density = $100/80 = 1.25$. (2) Baumé, for liquids heavier than water. Water at 17.5° C. = 0°; an aqueous solution containing 10 per cent. by weight of common salt (NaCl) at 17.5° C. = 10°; the scale is uniformly graduated; specific density = $146.8 \div (146.8 - n)$. (3) Baumé, for liquids lighter than water; 10 per cent. by weight salt-solution at 12.5° C. = 0°; water at 12.5° C. = 10°; specific density = $146 \div (136 + n)$. (4) 'Rational' Baumé, for liquids heavier than water; water at 15° C. = 0°; sulphuric acid, specific density = 1.842 = 66°; specific density = $144.3 \div (144.3 - n)$. (5) Cartier, resembles Baumé; for liquids lighter than water, 21° Cartier = 21° Baumé; otherwise 15 Cartier degrees = 16 Baumé degrees; specific density = $136.8 \div (126.1 \mp n)$. (6) Beck; pure water = 0°; specific density, 0.850 = -30°; uniform graduation; specific density = $170 \div (170 \mp n)$. (7) Twaddell, most used in England; water = 0°; graduation not uniform, but readings direct; specific density = $(1000 + 5n) \div 1000$ —e.g. a gallon of acid of 24° Twaddell weighs 10 lb. $\times \frac{1000 + 120}{1000} = 10 \text{ lb.} \times 1.12 = 11.2 \text{ lb.}$ (8) Tralles, an alcoholometer scale used on the Continent, adjusted so as to show directly the volume-percentage of alcohol in alcohol and water. (9) Sikes, used in the British Customs and Excise; graduated so as to show how many volumes of water must be added to or taken from 100 volumes of the mixture under examination to reduce it to proof-spirit (a mixture whose density = $\frac{1}{2}$ that of water at 51° F.—i.e. 57.09° Tralles), the instrument being adjustable to different ranges of density by a set of movable weights. Instead of making the quantity of liquid displaced to vary, as in the above instruments, the displacement may be kept constant and the weight of the instrument varied. Fig. 2 shows Nicholson's areometer—a hollow brass case, BC; cups at A and D; a weight at E. Suppose it weighs 2000 grains; and let it sink in water to a certain mark between B and A when 500 grains weight is put in A. If it be now transferred to another liquid in which only 250 grains are required



Fig. 2.

to make it sink to the same mark, the second liquid is lighter than water in the ratio of 2250, the whole weight of the apparatus, to 2500, its former whole weight; and its specific density is therefore $\frac{2250}{2500} = 0.9$. The same instrument may be used to find the specific density of small solids thus: put a little stone or gem in A; to make the apparatus sink to the mark say 440 grains are required; therefore the stone weighs 60 grains. Now put it in D. More weights, say 20 grains, must now be put in A; the 20 grains represent the apparent loss of weight in water; the specific density = weight in air ÷ apparent loss in water = $\frac{440}{20} = 22$. By reversing D, which is perforated, the specific density of bodies lighter than water may be ascertained. Fahrenheit's areometer, the original form, differs from Nicholson's in having no platform or cup D. Rousseau's densimeter combines the two methods described above. It bears a cup or cavity at its summit. This is filled successively with various liquids; each induces a different amount of sinking. The instrument-maker has to do the preliminary graduation by the use of known liquids. Specific-gravity bulbs are also used; they are marked with numbers representing specific densities. Those which are too heavy sink; those which are too light float; the one exactly corresponding to the density of the liquid, if there be one, neither rises nor sinks. The most accurate method is that by the specific gravity flask. The

specific density of a gas or vapour is determined (1) by weighing a copper flask when empty, when filled with the gas, and when filled with air, which method gives the density of the gas relatively to that of air, when proper corrections are made so as to compare the two gases at the same temperature and pressure; (2) by ascertaining the volume occupied by a given weight of the gas or vapour at a known temperature and pressure; (3) by measuring the weight of vapour which can occupy a known volume, this being effected by putting liquid into a vessel of known capacity and heating until there is, at a known temperature and the atmospheric pressure, nothing but vapour in the vessel, then closing and weighing when cool. The last two methods are specially applicable to vapours rather than to permanent gases. It is often convenient, instead of taking the true specific density of a gas or vapour—e.g. that of air, the number of grammes per cubic centimetre of which is 0.0012932—to state its density as compared with air or hydrogen as a standard. In this way air is said to have a density = 1 or = 1.47, according as air or hydrogen is taken as the standard. The use of hydrogen as a standard is of special convenience in chemical calculations, for the densities of gases or vapours so measured are, as a rule, proportional to their molecular weights. The following are the specific densities of some common substances:

Air.....	0.0012932	Granite.....	2.5 to 2.9
Alcohol.....	0.80	Honey.....	1.45
Aluminium.....	2.56 to 2.67	Human body alive.....	0.99
Amber.....	1.08	Hydrochloric acid (= 4.44 times that of air or 0.411 times that of hydrogen)	0.00574
Ammonia gas (= 0.589 x air).....	0.000762	Hydrochloric acid gas (= 1.28 x air).....	0.00163
Ammonia solution.....	0.88	Hydrochloric acid solution at 32° F.....	0.908
Amorphous arsenic.....	4.71	Hydrocyanic acid gas (= 0.9475 x air).....	0.1225
Anthracite.....	1.4 to 1.7	Hydrogen (= 0.08925 x air).....	0.00008958
Antimony.....	6.715	Ice.....	0.91674
Arsenic crystals.....	5.73	Iridium.....	22.42
Ash.....	0.84	Ivory.....	1.8 to 1.9
Bismuth.....	9.9	Lead.....	11.37
Blood.....	1.04	Lignum-vitæ.....	1.33
Bone.....	1.6 to 2.0	Limestone.....	2.5 to 2.8
Brown coal.....	1.2 to 1.4	Liquefied oxygen.....	1.124
Butter.....	0.94	Lithium.....	0.5936
Calcium.....	1.678	Leadstone.....	4.9 to 5.2
Cannel coal.....	1.16 to 1.27	Manganese.....	7.2
Carbonic acid gas (= 1.524 x air).....	0.00197	Marble.....	2.5 to 2.8
Cast-iron.....	7 to 7.6	Mercury.....	13.59
Chalk.....	2.45	Milk.....	1.03
Charcoal.....	0.8 to 0.5	Nitric acid.....	1.517
Chlorine (2.4502 x air).....	0.00317	Nitrogen (0.9713 x air).....	0.00128
Clay.....	1.8 to 2.6	Oak, English.....	0.97
Cobalt.....	8.96	Oil of cloves.....	1.03
Copper.....	8.95 to 8.94	Oil of turpentine.....	0.87
Cork.....	0.24	Olephant gas (= 1.9784 x air).....	0.01265
Cyanogen (1.906 x air).....	0.00234	Oxygen (= 1.1056 x air).....	0.00143
Diamond.....	3.53 to 3.55		
Dry peat.....	0.5		
Elm.....	0.67		
Flint.....	2.6 to 2.7		
Glass.....	2.4 to 2.5		
Gold.....	19.26 to 19.55		

Platinum.....	21.1 to 21.7	Steel.....	7.6 to 7.8
Poplar.....	0.38	Sulphuric acid.....	1.854
Potassium.....	0.86	Sulphuric ether.....	0.72
Ruby.....	4.3	Sulphurous acid gas (= 2.24 x air).....	0.0029
Sand in bulk, dry, about.....	1.5	Tin.....	7.29
" " wet.....	1.9 to 2.0	Topaz.....	3.4 to 3.6
Silver.....	10.53	Wrought-iron.....	7.25 to 7.79
Sodium.....	0.972	Zinc.....	6.86 to 7.21
Spanish mahogany.....	1.06		

Specific Gravity, the weight of any given substance as compared with the weight of an equal bulk or volume of water or other standard substance at the same temperature and pressure. See SPECIFIC DENSITY.

Speculum Metal, an alloy used for the specula or mirrors of reflecting telescopes. The best is composed of 128 parts of copper and 58.9 of tin. It takes a fine polish and is not easily tarnished unless exposed to damp. Glass with a film of metallic silver deposited upon it is now taking the place of speculum metal for these mirrors. The silvered glass is equally serviceable and less costly. See TELESCOPE.

Spence's Metal is made by melting together a metallic sulphide, such as sulphide of iron (iron pyrites), along with sulphur. The result is a grayish-black substance, without metallic lustre, which takes a good polish. It can be coloured to imitate bronze and other metals, and as it melts at 320° F. it can readily be cast into moulds from which it takes a sharp impression. Busts, medallions, &c. have been made of it, and it is also used like lead for the joints of pipes. It is but slightly acted on by acids. First made in 1879, it is more of the nature of a hard cement than a metal.

Spermaceti is a waxy matter obtained mixed with oil from the head of the sperm-whale, *Physeter macrocephalus*. The mass obtained from an ordinary sized whale would fill twelve barrels. It is purified by draining off the oil and repeatedly washing with hot water and weak boiling potash-lye. It is in white, pearly, semi-transparent masses, somewhat unctuous to the touch, lighter than water, and melting a little above 100° (38° C.). It is insoluble in water, but soluble in ether, chloroform, &c. Medicinally it is no longer given internally, but it is an ingredient of many ointments, to which it gives a crystalline appearance. Chemically it is almost pure cetyl palmitate, but contains small quantities of other fats.

Spinal Column and Spinal Cord. The spine or spinal column is the most important and characteristic part of the Skeleton (q.v.) of the highest division of the animal kingdom. It is composed of a series of bones placed one above, or in front of another, and called vertebrae; and hence these animals, having this distinguishing characteristic in common, are all included in the term *Vertebrates*. The vertebrae vary greatly in number in different animals, and even in members of the same class, and the number bears no apparent relation to the other organs of the animal. Moreover, in their shape they differ extremely even in different parts of the same spine, in accordance with their special functions. In man the number of vertebrae which collectively form the spinal column is 7 in the neck (cervical vertebrae), 12 in the back (dorsal vertebrae), 5 in the loins (lumbar vertebrae), all of which are capable of being detached from one another, and are termed *true vertebrae*; and 5 vertebrae ossified together and forming the sacrum, and 4 or 5 similarly united forming the termination of the column, and constituting the bone called the coccyx, which are known as *false vertebrae*. However long or short the neck may be, every mammal has 7 cervical vertebrae, excepting the three-toed sloth which has 9, and the sea-cow which has 6. In the other regions of the spine no such uniformity exists. Each vertebra is attached to the two between which it lies by numerous strong and more or less elastic ligaments, and between each pair of vertebrae there is interposed a lenticular disc of fibro-cartilage, which acts as a buffer. By these arrangements the spinal column is rendered highly elastic, the communication of jars or shocks is prevented, and a very considerable general range of movement permitted, although the motion between any two adjacent vertebrae is slight. The elasticity of the column is further increased by the component vertebrae being arranged in curves instead of being placed perpen-

dicularly. The curves should be exactly in the antero-posterior direction, any well-marked lateral deviation from the perpendicular being abnormal; but a very slight lateral curvature with the convexity to the right may often be detected in the upper and middle parts of the back, and is supposed to be dependent on the more frequent use and greater strength of the

right arm as compared with the left. From their position they are termed the cervical, dorsal, lumbar, and pelvic curves. The dorsal and pelvic curves have their concavities in front, and thus enlarge the spaces in which the thoracic and pelvic viscera are contained; the two other curves are convex anteriorly, and thus afford support to the parts above them. The upper three curves are so arranged that their cords are in the same vertical line in the erect position of the body, and this vertical line corresponds with the line of gravity of the head. The cause of these curves is to be sought for partly in the shape of the vertebral bodies, and partly in that of the intervertebral substance. Amongst the uses of these curves it may be mentioned (1) that they enable the spine to bear a greater vertical weight than it could otherwise maintain; it is calculated that nine times as great a vertical force is required to bend it as if it had been straight; (2) that they facilitate the movements of the body, especially in the act of running; and (3) that they are so disposed as to protect the cord in movements of the spine. Similar curves are seen in the spine of other mammals (see ANTHROPOID APES), though the degree of flexure is liable to great deviations. The lumbar curve, which has especial reference to the erect position, is always much less marked than in man.

The vertebral canal formed by the apposition of the spinal foramina or neural arches, and containing and protecting the spinal cord, varies in its size at different parts of the column. It is largest in its antero-posterior diameter in the neck and loins (measuring at the last lumbar vertebra $\frac{1}{2}$ of an inch), where the antero-posterior movements of the spine are greatest, and where the cord is least closely attached to the vertebrae; while in its lateral diameter it is greatest at the atlas, where it measures nearly an inch and a half. A transverse section of the canal is nearly circular through the greater part of the back. The intervertebral foramina through which the nerves emerge vary in shape and position in different parts, but are always of sufficient size to prevent injurious pressure on the nerves during movement of the spine; and in the dorsal region, which is the ordinary seat of angular curvature, the nerves are so protected by bony arches that they may escape injury, even when the bodies of several dorsal vertebrae have been destroyed by ulceration.

The *spinal cord* is that part of the central nervous axis which is contained within the vertebral or spinal canal. In man it extends from the foramen magnum, where it becomes continuous with the medulla oblongata, as far down as the lower border of the first lumbar vertebra. Below this point it is continued as a narrow thread containing little nervous matter, the *filum terminale*. The cord is, like the brain, encased in a triple sheath of membranes, the pia, arachnoid, and dura mater, the last two of which are less closely

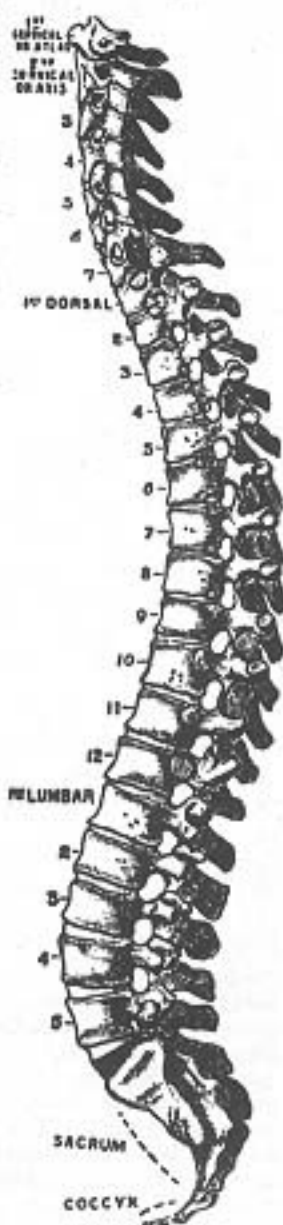


Fig. 1.—Spinal Column.

opposed to the cord and the vertebral column than they are to the brain and the cranium. The cord is a somewhat flattened cylinder or column of a whitish colour. It is divided into two lateral halves by an anterior median fissure and a posterior median septum. The former is less deep but wider than the latter, which is merely a process of pia mater. From each side of the cord thirty-one pairs of spinal nerves arise, each by an anterior and a posterior root (see NERVOUS SYSTEM). The cord is not of uniform circumference throughout. There is a slight thickening where the brachial nerves, and another where the lumbar nerves, arise. These are termed the brachial or cervical and lumbar enlargements respectively. The nerve roots in the cervical and dorsal regions pass nearly transversely outwards through the intervertebral foramina; but the lumbar and sacral nerves are directed downwards to attain their points of exit, in such a manner as to obtain the name of *Cauda Equina*.

The cord is seen to be composed of white and gray matter. On a transverse section the gray matter is found in the centre to present the appearance of a double crescent, concave outwards, with a commissural band between the two sides, so that the whole somewhat resembles the letter H. In the gray commissure is the *central canal*, which extends throughout the whole length of the cord and becomes continuous above with the fourth ventricle. The gray matter is divided into an anterior and a posterior horn. It is composed of a basis of connective tissue in which are a fine felt-work of nerve-fibres and nerve-cells. In the anterior horn, which becomes specially developed in the brachial and lumbar enlargements, the cells are of the multipolar type. They send a well-marked axis cylinder process into the anterior nerve root, and by their other processes are connected with fibres which descend from the cerebrum and from the posterior roots and other sources. In the posterior horn the nerve-cells are smaller, rounded, or spindle-shaped, and possess no axis cylinder process. They are probably connected with the posterior roots.

The white matter of the cord is composed of nerve-fibres, united by a small amount of connective tissue. The fibres have mostly a longitudinal direction, with the exception of a small strand which crosses from one side to the other at the bottom of the anterior median fissure—the anterior white commissure. Each half of the cord is divided by the anterior and posterior roots into three columns, named anterior, lateral, and posterior. Though these look almost exactly alike both to the naked eye and under the microscope, they can, by taking advantage of the facts that their component fibres are not all developed simultaneously, and that as the result of injury they do not 'degenerate' in the same direction or to the same extent, be further subdivided. Thus the posterior column is composed of two tracts—a postero-median and a postero-lateral. In the lateral column there can be distinguished five tracts: a direct cerebellar, an ascending antero-lateral tract, a crossed pyramidal tract, a lateral limiting layer, and a lateral mixed zone; while the anterior column consists of a direct pyramidal tract and an anterior mixed zone. The relations of these tracts have been fairly definitely established. The postero-median column is nearly entirely composed of fibres of the posterior roots which, after entering the cord and passing for a short distance in the postero-external column, are continued upwards as high as the medulla oblongata, where they end. This column then will form a direct path of connection of the posterior roots with the medulla oblongata. The direct cerebellar tract connects a column of nerve-cells in the posterior horn of the lumbar and dorsal regions of the cord (which is termed Clarke's vesicular column) with the middle lobe of the cerebellum. The antero-lateral tract appears to connect the nerve-cells in the posterior horn of one side of the cord with the medulla oblongata of the opposite side. All these tracts degenerate, and presumably also

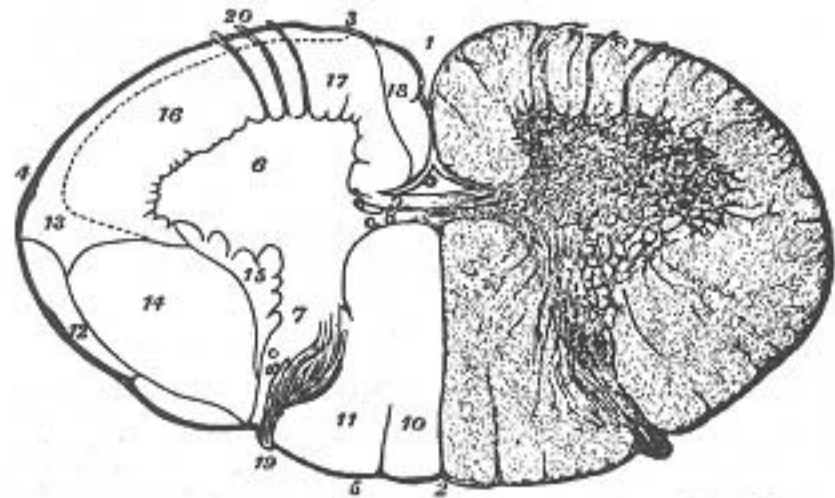


Fig. 2.—Section of Spinal Cord (outline of tracts shown on left side):

1, anterior median fissure; 2, posterior median septum; 3, 4, 5, anterior, lateral, and posterior white columns; 6, 7, anterior and posterior horns of gray matter; 8, 9, anterior and posterior commissures; 10, posterior median column; 11, posterior lateral column; 12, direct cerebellar tract; 13, antero-lateral ascending tract; 14, crossed pyramidal tract; 15, lateral limiting layer; 16, 17, lateral and anterior mixed zone; 18, anterior pyramidal tract; 19, posterior, and 20, anterior roots.

conduct nervous impulses in an upward direction. The direct and crossed pyramidal tracts form the downward continuation of the 'motor'-fibres from the surface of the brain to the cells in the anterior cornu of the cord. At the lower end of the medulla oblongata (see BRAIN, fig. 7) the greater part of the fibres of the anterior pyramids cross the middle line and descend in the crossed pyramidal tract of the cord to become connected with the motor-cells in the anterior horn. The direct pyramidal tract represents a small remnant of the fibres which descend in the cord without crossing to the opposite side. They cannot as a rule be traced further than the cervical region. Both of these tracts are undoubtedly concerned in the transmission of voluntary motor impulses from the brain. Their degeneration always accompanies paralysis of cerebral origin.

The tracts which lie in immediate contact with the gray matter, the antero-lateral mixed zone, the lateral limiting layer, and the postero-external column, probably form connections between different levels of the cord. Thus the postero-external column is in great part formed of fibres of the posterior roots passing upwards or downwards for a certain distance in it before entering the postero-internal column; while the antero-lateral mixed zone contains fibres which connect either nerve-cells at different levels, or more probably nerve-cells of one level with fibres which enter the anterior roots at another.

Functions.—The spinal cord provides paths for the conduction of afferent and efferent impulses to and from the brain, and also between different portions of its own substance, as well as arrangements for co-ordination of movements of the muscles of the trunk and limbs, and centres for the regulation of certain of the 'organic' functions of the body.

The efferent impulses are motor, vasomotor, and secretory. The path for the first of these is perfectly well known. It passes from the cerebral cortex (motor area) through the internal capsule and the anterior pyramids of the medulla mainly to the crossed pyramidal tract of the opposite side, and thence, as described, to the cells in the anterior cornu. It is not yet known whether the ultimate destination of the fibres of the direct pyramidal tract is the cells of the anterior horn of the same or those of the opposite side. The fibres from the vasomotor centre in the medulla in all probability pass down in the crossed pyramidal tract and leave the cord by the anterior roots. Division of their path leads to paralysis of the muscular walls and dilatation of the arteries. This is only temporary, as there are probably also centres in the cord which can act independently of those in the medulla. The other efferent paths are unknown.

The afferent paths transmit the various forms of sensory impulses; but, though we may perhaps assume that those which degenerate upwards also conduct in the same direction, it is remarkable how little is known definitely about these. It is generally held that impulses from the muscles pass up the same side of the cord either in the postero-median or direct cerebellar tracts; while the other sensory paths cross the cord as soon as they enter it, and are continued upwards along the

other side. It is not determined whether the crossing is complete, or whether the path is in the white or gray matter or in both. Probably it is not identical for each variety of sensation. There is some reason to believe that impulses which give rise to painful sensations travel up the ascending antero-lateral tract.

The cord also has in its anterior cornu cells which, when stimulated either from the brain or from the sensory nerves, originate voluntary or reflex muscular movements. These cells fulfil too the function of keeping up the general tone of the muscles and also their nutrition, for when they are destroyed the nerves and muscles connected with them waste and disappear. In certain regions of the cord these cells form centres for various of the organic functions. These are found mostly in the lower dorsal and lumbar regions. Recent experimental research by Ferrier and Yeo has determined the levels in the cord of the centres for the various movements of the limbs and trunk, and has already given valuable results in practical surgery.

See Quain's *Anatomy*, Obersteiner's *Anatomy of the Central Nervous Organs* (Hill's trans.), Landolt and Stirling's *Physiology*, and Foster's *Physiology*.

CURVATURE OF THE SPINE.—There are two main forms of this disease, which are due to different causes—viz. Angular Curvature or Pott's Curvature, and Lateral Curvature.

Angular curvature, which was first described by the famous surgeon Percival Pott (1713-88), and is hence often named after him, is due to disease of the bodies of the vertebrae and of the intervertebral discs. It usually takes the form of a tubercular disease of the bones, which become carious and destroyed, and of ulceration of the discs between them. The result is that the bodies of the diseased vertebrae give way and the column becomes bent forward on itself, while the spinous processes form a backward projection opposite the diseased part—hence the name angular curvature. This projection is most marked when the disease is in the dorsal region of the spine. If the disease is arrested the bones become firmly united, and the curve of the spine becomes permanent. In unfavourable cases abscesses may develop in the neighbourhood, and either press on the spinal cord or on the spinal nerves, or burrow in various directions, notably in the lumbar region (psoas abscess). The disease is often set up by an injury which may be severe, such as the falling of a heavy weight on the back, or in children may be some trifling twist or fall, such as may occur during rough play or from falling out of bed or from a chair. It most often occurs in delicate children with a tubercular family history, but it is by no means unknown in those whose family and personal history is quite unexceptionable, and it may even affect adults. Its early symptoms are often obscure, and consequently may be overlooked at a time when treatment is of most avail. There is at first little or no deformity, but there may be pain on percussing the spine of the affected vertebrae. There is also usually an avoidance of all movements which may lead to jarring of the spinal column or to painful pressure on the nerves. If the vertebrae of the neck are affected the child often supports its chin by the hands, and does not willingly turn

its head round. Disease of the dorsal or lumbar vertebrae is generally indicated by cautious movements, especially in coming down a stair, the avoidance of stooping or bending, or sudden twisting of the body. A child will thus get down on its knees to pick anything off the floor rather than stoop.

The treatment requires to be both local and constitutional. It is always protracted for months or even years. The general treatment is mainly that required for strumous constitutions, such as cod-liver-oil, iron, hypophosphite of lime, &c. The local treatment involves absolute rest in the recumbent position in the early stage, with counter irritation over the spine in the neighbourhood of the disease. In later stages mechanical supports are also required to keep the vertebrae from pressing on each other. The kind of support needed varies with the region affected; one very valuable form for hospital practice consists in the application, during the suspension of the patient, of a plaster of Paris jacket to the body. The more carefully rest in the recumbent position and mechanical support are carried out, the less, as a rule, will be the resulting deformity, the greater the prospect of avoiding complications and of obtaining permanent cure.

Lateral curvature consists in a twisting of the bodies of the vertebrae on each other round their vertical axis. It is sometimes a result of rickets, but is far more frequently developed in growing girls of feeble muscular development and general health,

between the ages of ten and sixteen. It is produced in the first instance by the continued maintenance of asymmetrical positions of the body, such as by sitting sideways or cross-legged before a school-desk, or by carrying a weight on one arm. This curvature is usually to the right in the dorsal region with a corresponding twist to the left in the lumbar region. One shoulder, usually the right, becomes elevated, and the scapula projects, while the right side of the chest becomes rounded and the left side flattened. The lungs and liver become compressed and subject to disease, and the gait becomes awkward. This disease is due in the first instance to rotation of the bodies of the vertebrae on each other as the result of the irregular pressure. Later the ligaments and articular processes of the vertebrae undergo permanent changes, while the muscles may atrophy or undergo fatty degeneration. The ribs also become distorted, those at the side of the convexity of the curve bending at the angles, those at the other side becoming flattened.

The treatment of this form differs entirely from that of angular curvature. As the disease is due to the continuance of asymmetrical positions of the body, combined with muscular and general debility, general tonics, fresh air, and gymnastic exercise specially directed to the strengthening of the weakened muscles must be adopted. In the later stages, when the deformity has become more confirmed, mechanical supports may be required as an adjunct to the above.

SPINA BIFIDA is a congenital malformation occurring perhaps more frequently than any other except hare-lip, and arising like it from arrest of development. It may be regarded as a congenital hernia of the membranes of the spinal cord through a fissure in the wall of the bony canal. A tumour is thus formed, which is usually of a roundish shape varying in size from that of an egg to that of an adult head, lying in the middle line of the back, fluctuating, and adhering to the adjacent vertebrae either directly or by a pedicle. The usual termination of the disease is death. As the size of the tumour increases, fatal convulsions ensue; or the skin investing the tumour may ulcerate and the contents escape, in which case palsy or convulsion produces death. Occasional cases are, however, recorded in which patients with this affection have survived till middle life. Surgical treatment has, until quite recently, been unsatisfactory; but with improved modern methods successful results have in many cases been obtained. Moderate support by means of a hollow truss, or a well-padded concave shield, may tend to keep the disease stationary; and any interference beyond this is, in the great majority of cases, inadvisable.

Spinning is the art of twisting fibrous substances into rounded strands of yarn fitted for weaving, or for thread or rope making. To form such strands two operations are essential—(1) the

drawing out of uniform quantities of fibre in a continuous manner, and (2) twisting the material so drawn out to give it coherency and strain-resisting power. The earliest and for ages the only spinning apparatus was the spindle with the distaff. The latter was a stick or staff upon which a bundle of the fibre to be spun was loosely bound, and it was either held in the left hand or stuck in the belt. The spindle (fig. 1) was a smaller tapering rod, the rotation of which gave the twist, and around which the thread was wound as it was twisted. The twist was given by causing the spindle to rotate against the person, and allowing it to fall towards the ground whilst spinning around. To give the spindle increased momentum it was weighted with a whorl (fig. 1) of stone or metal, but as the weight of the yarn on it increased this make-weight was removed. A graphic description of this method of spinning is given by a Scotch rhymester of the 18th century.

To save their plaiding coats some had
Upo' the haunch a bonnet braid
Or an auld wecht or kailing skin
To rub and gar the spindle rin
Down to the ground wi' twirling speed
An' twine upo' the floor the thread.

Simple as it is, the spindle has continued in use from prehistoric times to the present day. In some outlying regions of the Scottish Highlands and Islands, according to Sir Arthur Mitchell (*The Past in the Present*, Rhind Lectures, Edin. 1880), yarn is still made with it, and in the East Indies the exceedingly delicate yarn for Dacca (q.v.) muslins is made on the spindle. The first improvement on this simple apparatus consisted in fixing the spindle in bearings and causing it to rotate by a belt passed over a wheel. Next came the fitting on the spindle of a separate bobbin to receive the spun yarn, and this in effect constitutes the charka or spinning-wheel of the East, which has there been used from time immemorial, and also the 'muckle wheel,' the use of which continued in Scotland till recent times. This simple wheel was known in Europe as early as the 14th century, but the greatly improved small or Saxon wheel (fig. 2), with a treadle motion giving continuous rotation to the spindle and allowing the spinner to sit with both



Fig. 2.—Two-handed Spinning-wheel.

hands free, was not known till much later times. In the spinning-wheel in its improved form a bobbin or pirn with a separate motion was placed on the spindle (fig. 3), which had two bent arms, the flyer or flight, for winding the yarn on the bobbin. The bobbin and flyer revolved at different rates—the revolutions of the spindle giving the twists and the difference of rotation causing the winding on. In such wheels it was possible to have two spindles and pirns a little apart (the two-handed wheel, fig. 2), with distaff or rock between them, and on these the spinster produced thread with each hand. The introduction of mechanical spinning towards the end of the 18th century gave a death-blow to this great domestic industry, but in the Northern and Western Highlands of Scotland a good deal of worsted yarn still continues to be made for local manufactures on spinning-wheels.

The series of inventions which overthrew hand-spinning may be said to have been begun by Lewis Paul in 1738, when he patented the important principle of drawing out and attenuating a sliver or

loose coil of fibre by passing it between successive pairs of rollers revolving at increasing rates of velocity. This principle of drawing out fibres by accelerated motion was developed in the spinning-frame or throstle invented by Arkwright in 1767, and it forms a fundamental feature of all modern spinning machinery. About 1764 James Hargreaves at Standhill, near Blackburn, invented his spinning-jenny (fig. 4), an apparatus by which eight threads could be spun at once, and this was soon improved upon until eighty could be produced as easily. In this apparatus a number of large reels filled with thickish coils of fibre called rovings were set on upright fixed spindles, and the end of these rovings was passed between two small movable bars of wood placed horizontally and under the control of the spinner, who could thus make them press more or less on the roving, and consequently increase or decrease the draw upon it from the spinning-spindles, which were set in a row at the other end of the frame.



Fig. 3.—Spindle, Bobbin, and Flyer of fig. 2 on larger scale.

These spinning-spindles gave the twist to the rovings when they were fully drawn out, and thereafter wound on themselves the twisted yarn by being moved in the frame towards the bobbins of roving whilst they continued to rotate. The principle of the jenny was important and, developed in the spinning-mule of Crompton in 1779, it is the basis of the second of the two great methods of machine-spinning now in use.

While the operation of spinning is one of the simplest of all arts, requiring as we have seen only the aid of two short pieces of stick, its modern developments have produced more delicate and varied mechanical devices, and have called forth more inventive ingenuity, than any other industrial operation. To convey an adequate idea of the variety of machines used in any single branch of the spinning trade, and of their highly complicated structure, would require much more space than can be here afforded. Different kinds of fibre require different treatment and special machines; and, moreover, yarns of the same fibrous material may be prepared and spun in several different ways according to the uses for which they are intended and other circumstances. Spinning thus becomes a complicated and delicate art, varying widely according to the material treated and the purpose to which the yarn is to be devoted. Dealing with wool, for example, the treatment of that fibre for the production of worsted and of woollen yarns is diametrically opposite. For worsted yarns long staple wools are employed. These are combed so as to separate the short fibres—the 'noils'—from the long or 'top' fibres. The 'top' afterwards passes through a long series of operations, the principal object of which is to lay every single fibre as nearly as possible parallel and level with its neighbour. For woollen yarn, on the other hand, short staple and wavy wools are used. These are carded together so that the fibres may as far as possible cross each other and interlace before being spun, and these peculiarities form the essential distinction between woollens and worsteds. Apart from worsteds, however, there is a general

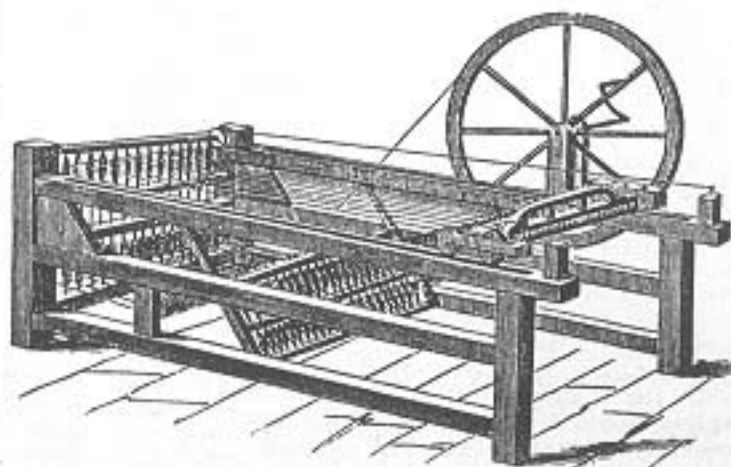


Fig. 4.—Hargreaves' Jenny.

sequence in the treatment of all fibres which may be here briefly outlined.

The object of all operations preliminary to the actual spinning is (1) to free the fibres from all extraneous matter; (2) to lay them side by side in level parallel order; (3) to pull them out in a continuous strand or sliver of uniform thickness; and (4) to attenuate this sliver till the quantity required to form the yarn is reached. The operations necessary for these purposes, combined with a properly regulated amount of twist, constitute the conditions necessary to produce sound, level, and uniform yarn.

Taking the case of cotton, the opening and partial cleaning of the matted fibres are secured by passing the material through two machines called respectively the opener and the scutcher. In these machines are cylinders revolving at a high rate of speed, with their surfaces studded with stout teeth which seize separate flocks of the fibre and carrying it round form a broad uniform teased mass which is called a lap. In the first of these machines it is

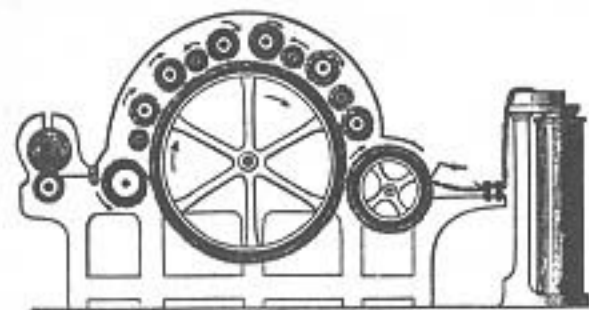


Fig. 5.—Sections of Carding-engine.

also submitted to a strong current of air which blows dust and dirt out of the cotton. From the scutcher a well opened and spread lap of the fibre is delivered to the carding-engine (fig. 5), in which a series of cylinders of various sizes, and rotating at different velocities, further open and tease the fibre. The cylinders are covered with teeth of fine wire (fig. 6) bent at about half their length,

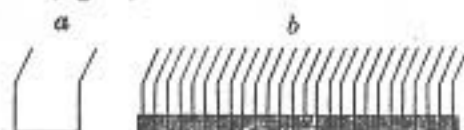


Fig. 6.
a, card wire; b, card setting.

of which there may be from six to seven millions in a single machine. According to the direction in which the cylinders rotate, and the rate of their revolution, the wire points may meet each other, or the points and flat sides of the wires may meet and pass; and in this way certain cylinders lift the fibres from their neighbours and pass it on to others, so that the fibre is gradually teased, brushed, and spread out in a uniform manner. From the carding-engine the fibre is delivered in a broad lap; but by passing it through a ring or tube it is compressed into a soft rounded coil or sliver. This sliver is taken to the drawing-frame, which consists of say four successive pairs of rollers, each pair in succession going at a greatly accelerated rate, so that the last pair may be going six times quicker than the front pair. In this way a sliver is drawn out six times its original length, and six slivers fed in come out the thickness of one. This drawing out ultimately brings the slivers to a very uniform thickness, and places the fibres in a parallel order. It may be repeated many times, and thereby the fibres which lay together in the original strand may be drawn out to a great length. Thus, passing a sliver of one yard three times through the drawing-frame elongates it $6 \times 6 \times 6 = 216$ yd., or four times passed through it is stretched out to 1296 yd. For fine yarns this drawing out frequently repeated may represent an elongation many thousandfold. In the slubbing-frame comes the beginning of the spinning process; the sliver being here further drawn out and twisted sufficiently to enable it to be wound on a bobbin. The intermediate frame draws out two slubbings to the thickness of one, again slightly twists it, and winds it on a bobbin. In the roving-frame the slubbing is drawn out further, slightly twisted, and wound on a bobbin. The rovings or bobbins of rove are then ready for the spinning-frame, which in the case of heavy stout yarns is invariably the throstle, but when

fine counts are spun the spinning is done on the mule. In throstle-spinning the roving is attenuated by passing between rollers increasing in speed till the desired tenacity is attained, at which point the final twist is given, and the yarn is wound on the bobbin or pirn ready to receive it.

There are three methods of twisting practised in throstle-spinning. The first and oldest is with spindle, bobbin, and flyer, in principle precisely the same as the arrangement in the spinning-wheel. The second method is cop-spinning, in which the spindle is stationary, but the bobbin which revolves around it is caused at once to give the twist and wind the yarn on its own surface. This is effected by fitting over the bobbin a steel cop or cover of sufficient dimensions to cover a filled bobbin. The cop has a smooth steel edge which keeps the yarn free from the bobbin while the twist is being put on, and which by its motion up and down regulates the winding of the finished yarn on the bobbin. The third and most recent development of throstle-spinning is the ring and traveller frame. In this both spindle and bobbin revolve together and give the twist; but the yarn passes to the bobbin through a traveller or eye of steel set on a flanged steel ring which encompasses the spindle and bobbin. The traveller keeps the yarn free from the bobbin while the twist is being put in, and being carried round by the bobbin it winds the yarn on the bobbin, the filling of which is regulated by an up-and-down motion communicated to the rail on which ring and traveller are fastened. In mule-spinning the bobbins of rove are mounted on a fixed frame, and corresponding yarn bobbins or paper cops are attached to the spindles, which are mounted on a carriage made to travel back and forward over a space of two yards or thereby. The spinning in this apparatus is intermittent. The drawing rollers at the fixed frame give out a certain length of roving; and simultaneously the carriage begins to move away, and the spindles rotating rapidly put twist on the rove. At a certain point the rollers cease to give off roving, but, the carriage still travelling backward and the spindles rotating, the yarn is further drawn out and correspondingly more twist is imparted. The twist becomes hardest at the points where the yarn is weakest, the drawing power of the carriage is exercised most on the thickest portions of the yarn, and thus twisting and drawing so compensate each other that yarn of great regularity is produced. When the carriage reaches its full stretch the yarn is completely spun, and in returning towards the frame the separate strands are lowered so that they are wound around the cops by their rotation. Then the operations are repeated, and go on doing to perhaps 200 strands of yarn by mechanical agency precisely the series of operations which for ages mankind with a single spindle did for a single strand of yarn—viz. drawing out, twisting, and ultimately winding up the finished yarn. Previous to the invention of the mule few spinners could make yarn of 200 hanks to the pound (the hank being always 840 yards). At the same time the natives of India were weaving yarn of numbers ranging between 300 and 400 (i.e. 400 hanks to the pound). Now, however, our manufacturers have reached such extraordinary perfection that Manchester spinners have made No. 700, which was woven by a French firm. No. 10,000, a pound of which would reach 4770 miles, has been made to test machinery.

Spirit, a name of very general application to fluids, mostly of a lighter specific character than water, and obtained by distillation. Thus, the essential oil of turpentine is called Spirit of Turpentine; a looser usage extended the name to Spirit of Nitre (nitric acid) and Spirit of Salt (hydrochloric acid). But in a stricter sense the term spirit is understood to mean Alcohol (q.v.) in its potable condition, of which there are very numerous varieties, deriving their special characters from the substances used in their production.

Spontaneous Combustion is a phenomenon that occasionally manifests itself in mineral and organic substances. For some facts connected with the spontaneous ignition of mineral substances, see PYROPHORUS. Ordinary charcoal does not undergo combustion in air below a temperature of 1000°, but in some states, especially when impregnated with oil, it is liable spontaneously to acquire a temperature which may lead to unexpected combustion. There have been many

instances of the spontaneous ignition of coals containing iron Pyrites (q.v.) when moistened with water. The pyrites which most readily give rise to spontaneous combustion are those in which the protosulphide is associated with the bisulphide of iron; and these occur among the Yorkshire coals and in some kinds of South Wales coal. Sulphur has no tendency to spontaneous combustion, but Dr Taylor refers to an instance that came to his own knowledge, in which there was reason to believe that the vapour of bisulphide of carbon in an india-rubber factory was ignited by solar heat traversing glass. Phosphorus, when in a dry state, has a great tendency to ignite spontaneously, and it has been observed to melt and take fire (when touched) in a room in which the temperature was under 70°. The ordinary lucifer-match composition is luminous in the dark in warm summer nights, which shows that oxidation, and therefore a process of heating, is going on. Hence large quantities of these matches kept in contact may produce a heat sufficient for their ignition. 'I have seen them ignite,' says Dr Taylor, 'as a result of exposure to the sun's rays for the purpose of drying.'

In organic substances, apart from the accidents that may result from the admixture of strong nitric or sulphuric acid with wool, straw, or certain essential oils, and which, if they occur, are immediate and obvious, there are many cases in which, 'without contact with any energetical chemical compounds, certain substances—such as hay, cotton and woody fibre generally, including tow, flax, hemp, jute, rags, leaves, spent tan, cocoa-nut fibre, straw in manure-heaps, &c.—when stacked in large quantities in a damp state, undergo a process of heating from simple oxidation (fermentation) or fermentation, and after a time may pass into a state of spontaneous combustion' (Taylor). Cotton, woollen articles, hemp, tow, and flax impregnated with oil, when collected in large quantity, are specially liable to ignite spontaneously; and the accumulation of cotton-waste, used in wiping lamps and the oiled surfaces of machinery, has more than once given rise to accidents, and led to unfounded charges of incendiarism. Dr Taylor relates a case in which a fire took place in a shop 'by reason of a quantity of oil having been spilled on dry sawdust.' According to Chevallier, vegetables boiled in oil furnish a residue which is liable to spontaneous ignition. The great fire at London Bridge in 1861 was referred to the spontaneous combustion of jute in its ordinary state; but Dr Taylor remarks that this is wholly incredible, and from experiments which he made for the defendants in the case of *Hepburn v. Lordan* (1865), and on other

grounds, he holds that there is even no evidence of moist jute undergoing spontaneous combustion. Dry wood is supposed by Chevallier and some other chemists to have the property of igniting spontaneously. Deal which has been dried by contact or contiguity with flues or pipes conveying hot water or steam at 212° is supposed to be in a condition for bursting into flame when air gets access to it; and the destruction of the Houses of Parliament, and many other great fires, have been ascribed to this cause; but it appears that some amount of charring is necessary, and that on slight cooling a considerable quantity of oxygen is absorbed from the air, which induces a sufficient rise of temperature to set up spontaneous combustion. In a case recorded in the *Annales d'Hygiène* for 1841, MM. Chevallier, Ollivier, and Devergie drew the conclusion that a barn had caught fire from the spontaneous combustion of damp oats which were stored in it. No such cases are known to have occurred in Great Britain. See also FIRE, p. 634; and GUN-COTTON, p. 468.

Spontaneous combustion of the human body is supposed to have occurred in a number of recorded cases, of which one of the earliest was that of Mme. Millet at Rheims in 1725, and one of the most notable that of a man found burning in bed in 1847 (*Gazette Médicale*, 4th September 1847). Some of the alleged cases have been traced to wilful burning after murder; some are plainly incredible; the remainder, with the exception of the 1847 case, which remains unexplained, can all be traced to the destruction of the bodies of intoxicated brandy-drinkers, near an open fire in winter, with no one present and no evidence forthcoming as to the time occupied in the combustion, or as to the circumstances, other than intoxication, preceding the combustion. Liebig discusses the subject in his *Letters on Chemistry*, and concludes that,

while a fat dead body charged with alcohol may perhaps burn, a living body, in which the blood is circulating, cannot take fire under any circumstances.

Starch, $C_6H_{10}O_5$. It is one of the essential functions of the leaves of plants to decompose carbonic acid, by the help of sunlight which shines through the chlorophyll, with evolution of oxygen and the formation of starch. The starch becomes converted by a diastatic ferment into sugar, which passes from the leaves to various parts of the plants, and being reconverted into starch, is stored. See CHLOROPHYLL, LEAF, and SEED. It is in this way that fruits and seeds, stems—e.g. that of the sago palm—tubers like the potato, tap-roots, bulb, &c. become stored with starch. The granules of starch are usually of a rounded form, consisting of a nucleus surrounded by a number of envelopes or layers. Each species of plant has its own peculiar

but it is otherwise largely used in the arts. By the further action of acids on starch *dextrase* or grape-sugar, and also the crystallisable sugar, *maltose*, are obtained. Maltose sugar is likewise produced during the operation of malting by the action of diastase on the starch of grain.

Starch is heard of in England as early as 1511, but was not much used till 1564, when, according to Planché, 'Mistress Bingham Vandh Plasse, a Fleming, came to London, and publicly taught the art of starching. . . . Stubbs falls foul of this "liquid matter which they call starch, wherein the devil hath learned them to wash and dive their ruffs, which being dry will then stand stiff and inflexible about their necks."'

Manufacture.—Starch is manufactured on a large scale in Europe from maize, wheat, rice, potatoes, and from sago-flour. *Maize-starch* is most largely made. The grain contains 65 per cent. of starch and about 14 of gluten and other nitrogenous matters. The Indian corn is first steeped for forty-eight hours in water at a temperature not exceeding 120° F. It is then ground with water by millstones into a milky state, after which it is sieved to keep back the husks. From the sieve the starchy liquid passes into 'runs' or channels made of wood, from 2½ to 4 feet broad and 9 inches deep, in which the starch deposits. It is then removed from the runs and put along with water into vats or tuns (10 feet in diameter and 4 feet 6 inches deep) provided with stirrers, some very weak soda-lye being added. After it is sufficiently stirred the liquid is allowed to settle, when the starch falls to the bottom. At this stage the vats contain a layer of starch, over this a layer of gluten, and above that again a stratum of yellowish water thick with gluten. The starch is again washed with water in the final settling vats, from which, after drawing off the water, it is removed and spread on clean cotton sheeting to be dried in stoves at a temperature between 120° and 130° F. A little chloride of lime is used to bleach maize and other kinds of starch.

Potato-starch.—In manufacturing starch from potatoes, the latter are first washed in machines of various kinds, but of which one of the simplest is a revolving cage-like cylinder with wooden bars. Then follows the grating of the washed potatoes by forcing them against the saw-like teeth of rasps, which, as sufficient water is fed to the machine, reduces them to a paste. In order to separate fibrous and albuminous matters and other impurities, the starch-paste with an addition of water is passed through fine sieves, and at the same time agitated by various arrangements. From the sieves it is received into settling tanks in which the deposit of starch is again washed in clean water. It then descends in a milky stream over an inclined plane, on which the starch is deposited, and afterwards once more washed. A little alum or sulphuric acid is used to assist in the removal of albuminous matters. The starch is dried either on porous bricks or on slabs of gypsum, and for some purposes it undergoes another drying in a hot chamber.

Wheat-starch.—Owing to the large amount of albuminous and other nitrogenous bodies (gluten or its equivalents) which wheat contains, amounting sometimes to more than 15 per cent., the methods of making starch from this grain are a little more complicated than the processes employed to obtain it from other cereals or potatoes. Wheat-starch is made by the old plan of removing the gluten by fermentation, and also by Martin's method of kneading the flour into a stiff dough and washing out the starch with water on a sieve. Good English wheat contains about 69 per cent. of starch, but in this grain the proportion of both starch and gluten varies much.

Rice-starch is prepared by removing the gluten, which amounts to from 7 to 8 per cent. of the seed, by the action of soda in weak solution. The proportion of starch in rice is higher than it is in other cereals, varying from a little under to a little over 80 per cent. The *corn-flours* of commerce are prepared either from the purified starch of maize or from that of rice. These flours, being nearly pure starches, with the flesh and bone forming constituents extracted, are not flours of their respective seeds in the sense that wheat-flour is.

Steam-engine. Steam-engines in their infancy were known as 'fire' (i.e. *heat*) engines; and in point of fact the older term is the more correct, because the water or steam is only used as

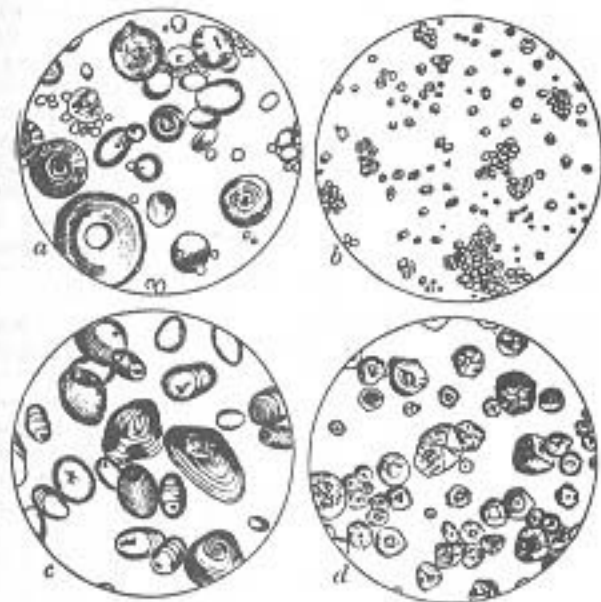
a convenient medium through which the form of energy which we call heat is made to perform the required mechanical operations. In modern engines sufficient heat is added to the steam to raise it to a very high pressure, and the excess of this pressure over the pressure opposed to it (either atmospheric pressure or the still lower pressure in a condenser) is both the cause and measure of the work done by the engine. In earlier machines, however, the steam was raised only to atmospheric pressure, and admitted into the engine only to be at once condensed by a jet of cold water. The excess of the atmospheric pressure above the pressure in the partial vacuum caused by the condensation was then the direct cause of work. Engines of this kind were called *atmospheric engines*.

The invention of steam as a moving power is claimed by various nations; but the first extensive employment of it, and most of the improvements made upon the steam-engine, the world indisputably owes to Britain and the United States.

Among the first notices we have in England of the idea of employing steam as a propelling force, is in *The Art of Gunnery* (1647), by Nat. Nye, mathematician; in which he proposes to 'charge a piece of ordnance without gunpowder,' by putting water instead of powder, ramming down an air-tight plug of wood, and then the shot, and applying a fire to the breach 'till it burst out suddenly.' But the first successful effort was that of the Marquis of Worcester. In his *Century of Inventions*, the manuscript of which dates from 1655, he describes a steam-apparatus by which he raised a column of water to the height of 40 feet. This, under the name of 'Fire-waterwork,' appears actually to have been at work at Vauxhall in 1656. Sir Samuel Morland in 1683 submitted to Louis XIV. a project for raising water by means of steam, accompanying it with ingenious calculations and tables. The first patent for the application of steam-power to various kinds of machines was taken out in 1698 by Captain Savery. In 1699 he exhibited before the Royal Society a working model of his invention. His engines were the first used to any extent in industrial operations; they seem to have been employed for some years in the drainage of mines in Cornwall and Devonshire. The essential improvement in them over the older ones was the use of a boiler separate from the vessel in which the steam did its work; one vessel in all former engines had served both purposes. He made use of the condensation of steam in a close vessel to produce a vacuum, and thus raise the water to a certain height, after which the elasticity of steam pressing upon its surface was made to raise it still further in a second vessel.

In all the attempts at pumping-engines hitherto made, including Savery's, the steam acted directly upon the water to be moved without any intervening part. To Denis Papin (q.v.), a French physicist, is due the idea of the *piston*. It was first used by him in a model constructed in 1690, where the cylinder was still made to do duty also as a boiler; but in an improved steam-pump invented about 1700 he used it as a diaphragm floating on the top of the water in a separate vessel, or cylinder, and the steam, by pressing on the top of it, forced the water out of the cylinder at the other end.

The next great step in advance was made about 1705 in the 'atmospheric' engine, conjointly invented by Newcomen (q.v.), Cawley, and Savery. This machine (fig. 1) held its own for nearly seventy years, and was very largely applied to mines. In it the previous inventions of the separate boiler and of the cylinder with its movable steam-tight piston are utilised, although in a new form. The 'beam,' which has ever since been used in pumping-engines, was used for the first time, and for the first time also the condensation of the steam was made an instantaneous process, instead of a slow and gradual one. Newcomen's engine was chiefly used, like all former steam-engines, in raising water. To one end of a beam moving on an axis, I, was attached the rod, N, of the pump to be worked; to the other the rod, M, of a piston, P, moving in a cylinder, C, below. The cylinder was placed over a boiler, B, and was connected with it by a pipe provided with a stopcock, V, to cut off or admit the steam. Suppose the pump-rod depressed, and the piston raised to the top of the cylinder—which was effected by weights suspended at the pump-end of the beam—the steam-cock was then turned to cut off the steam, and a dash of cold water was thrown into the cylinder by turning a cock, R, on a water-pipe,



Starch Granules:

a, wheat; b, rice; c, potato; d, maize: all magnified 250 diameters. (From Dr Bell's *Chemistry of Foods*.)

shape of granule which can be recognised under the microscope, but in the same plant these granules differ in size. The smallest size of a granule of oat-starch is .0001, while the largest sized granule of *Tous-les-mois* starch is about .0015 of an inch. In a small book on the *Chemistry of Foods*, by Dr Bell of the Somerset House Laboratory, the reader will find a considerable number of illustrations of starches as seen under the microscope.

Starch has the same elementary composition as sugar, gum, and woody fibre (cellulose). These all belong to a class of substances called carbohydrates, because they could be represented as compounds of carbon and water, as shown by the formula given above, which corresponds to six atoms of carbon and five molecules of water, H_2O . Starch contains no nitrogen, and is thus distinguished from characteristic animal compounds. The peculiar structure of starch granules and the way in which they occur in the vegetable cell permit of their being readily separated from other matters occurring along with them in plants. As usually prepared, starch is either a white glistening powder or it is obtained in irregular prisms which arise from the cracking up of a cake of the dried material. When pressed between the fingers a slight but peculiar sound is produced. Its specific gravity varies from 1.55 to 1.60. Starch is soluble only to a very slight extent in cold water, but when heated in water to above 150° F. the granules burst, and a clear ropy solution is formed which, on cooling, becomes a translucent jelly called *starch-paste*. This paste gives a deep blue colour with iodine and an orange yellow with bromine, the former being a highly characteristic and delicate test for starch. If a salt of iodine, such as iodide of potassium, is used, the iodine must be liberated either by a drop of strong nitric acid or preferably by a little chlorine water. By the gentle action of nitric acid on starch an explosive compound called *xyloidine* is obtained. At a temperature of about 320° F. (160° C.) starch is converted into *dextrine* or *British gum*, and the same change is produced on starch by the action of dilute mineral acids. Dextrine is usually made on an industrial scale from potato-starch. It is this Dextrine (q.v.) which is the adhesive matter on postage-stamps,

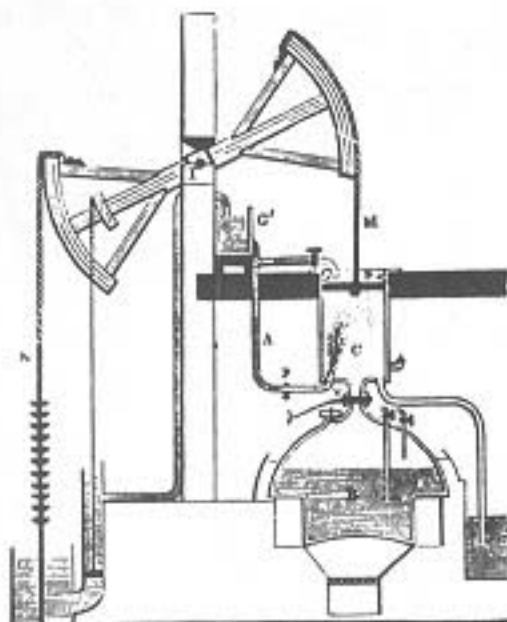


Fig. 1.

A, connected with a cistern, C'. This condensed the steam in the cylinder, and caused a vacuum below the piston, which was then forced down by the pressure of the atmosphere, bringing with it the end of the beam to which it was attached, and raising the other along with the pump-rod. The cock was then turned to admit fresh steam below the piston, which was raised by the counterpoise; and thus the motion began anew. The opening and shutting of the cocks was at first performed by an attendant, but subsequently a boy named Humphrey Potter (to save, it is said, the trouble of personal superintendence) devised a system of strings and levers by which the engine was made to work its own valves. In 1717 Henry Beighton, an F.R.S., invented a simpler and more scientific system of 'hand-gear,' which rendered the engine completely self-acting. During the latter part of the time that elapsed before Watt's discoveries changed everything Smeaton brought Newcomen's engine to a very high degree of perfection. As the result of study and experiment he made many improvements in it, in the form of the boiler, the proportions of the cylinder, &c. It was he, too, who invented the *cataract*, a very ingenious self-acting valve arrangement, which is still used in Cornish engines. In 1725 Leupold invented an engine in which steam of a higher pressure than that of the atmosphere was employed in the cylinder, but his engine possessed defects that prevented its practical use.

The next essential improvements on the steam-engine were those of Watt, which began a new era in the history of steam-power. The first and most important improvement made by Watt was the separate condenser, patented in 1769. He had observed that the jet of cold water thrown into the cylinder to condense the steam necessarily reduced the temperature of the cylinder so much that a great deal of the steam flowing in at each upward stroke of the piston was condensed before the cylinder got back the heat abstracted from it by the spurt of cold water used for condensing the steam in the cylinder. The loss of steam arising from this was so great that only about one-fourth of what was admitted into the cylinder was actually available as motive-power. Watt therefore provided a separate vessel in which to condense the steam, and which could be kept constantly in a state of vacuum, without the loss which arose when the cylinder itself was used as a condenser. This device, which now looks simple enough, was the greatest of Watt's inventions, and forms the foundation of his fame. His genius was such that in a few years he changed the steam-engine from a clumsy, wasteful, almost impracticable machine into a machine practically the same as that which we now have. The principal improvements since his time have been either in matters relating to the boiler; in details of construction consequent on our increased facilities, improving machinery, and greater knowledge of the strength of materials;

in the enlarged application of his principle of expansive working; or in the application of the steam-engine to the propulsion of carriages and vessels. His principal inventions were: (1) The condensation of steam in a vessel separate from the cylinder, so as to avoid the cooling of the

latter; (2) the use of a pump, called an 'air, pump,' to withdraw the condensed water and mixed steam and air from the condenser; (3) the surrounding of the cylinder with a steam-jacket, in order to prevent loss of heat from condensation (these three, with others, were included in the specification of 1769); (4) the use of the steam expansively in the way explained further on in this article (this was invented before 1769, but not published till 1782); and (5) the now universally used double-acting engine, and the conversion of the reciprocating motion of the beam into a rotary motion by means of a crank (both these were invented before 1778, the engine being patented in 1782, but the crank having before that date been pirated and patented by another). In 1784 Watt also patented and published his parallel motion, throttle-valve, governor, and indicator; all four of which are in substance still used.

The common mode of employing steam in an engine is by causing it to press alternately on the two surfaces of a movable diaphragm or piston enclosed in a fixed, steam-tight, cylindrical box. In fig. 2 A is the piston and B a section of the box. The piston, by means of a rod, E, passing through the end of the box, is made to communicate motion to the rest of the machinery. The steam is first admitted to one end of the cylinder through an opening or 'port,' D, and forces the piston along to the other end. The current of steam from the boiler is then allowed to pass into the other end of the cylinder through the opening C, and forces the piston back again to its original position, and so on. But it is obvious that while this return-motion is going on the steam previously admitted at D must be allowed some exit, or the piston could not be forced back. The manner of this exit constitutes the difference between the two principal classes of engines, according as the steam is allowed simply to rush out into the atmosphere or is conducted into a separate vessel, and there 'condensed.'

The simplest way in which steam can be used in a cylinder is at the same time the most wasteful. It consists in filling each end of the cylinder alternately full of steam direct from the boiler, and having the full boiler pressure, and thus forcing the piston along in exactly the same way as that in which it would have to be forced were water the fluid used instead of steam. If we imagine the cylinder to have a capacity of 7 cubic feet, then, if it be filled entirely with steam from the boiler at 60 lb. absolute pressure, it will contain (about) one pound-weight of steam. The total heat in this pound of steam (above 32° F.), as given in the table, is equivalent to 1171 thermal units in excess of that possessed by a pound of water at 32° F. When the piston, A, has reached the end of its stroke, the steam contained in the cylinder is thus in itself a great storehouse of work, for each of these thermal units is equivalent to 772 'foot-pounds' of mechanical energy, so that the total represents about 904,000 foot-pounds, of which we shall see later on only about $\frac{1}{4}$ has been utilised during the stroke, leaving $\frac{3}{4}$ untouched. Instead of making any attempt to utilise this huge balance, at the moment when the cylinder is full of steam

the opening C is put into communication with the boiler, the opening D with the atmosphere, and the steam immediately rushes out of the cylinder, and dissipates its contained energy through the air. Although the steam, when allowed to go into the atmosphere, is immediately reduced to the pressure corresponding to the temperature of the air (which in ordinary cases would be only a fraction of a pound per square inch), still the full pressure of the atmosphere itself will always be acting on the back of the piston during its stroke, and therefore, to find the force with which the piston is being pushed along, we must subtract that pressure from the steam-pressure. On the one side of the piston will be the atmosphere with its uniform pressure of nearly 15 lb. per square inch, and on the other side the steam-pressure of 60 lb. The effective pressure thus will be 60 - 15, or 45 lb. per square inch only.

Let us now consider the somewhat more economical case of an engine in which the steam is first used as described above, but afterwards, instead

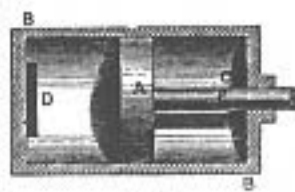


Fig. 2.

of being allowed to pass into the atmosphere, is conducted through a pipe into a closed vessel and there condensed. Condensation consists in the subtraction from steam of a portion of its sensible heat. This reduction of temperature has a double effect on the steam: (1) the cooling and liquefaction of a part of it; and (2) the reduction of the rest to the pressure corresponding to the reduced temperature. It is not possible to do one of these things without the other. What is commonly called 'vacuum' simply means pressure less than the atmospheric pressure; and, in the case of steam-engines, a vacuum generally implies a pressure of between 2 and 3 lb. per square inch—i.e. from a seventh to a fifth of the ordinary pressure of the air. The most common way of condensing steam is by bringing it into contact either with a jet of cold water or with surfaces kept continually cool by a current of water. In either case, directly the steam is brought into contact with the water or cooling surface, it transfers to it the larger portion of its sensible heat. During this process the greater part of the steam is liquefied, and the remainder retains only such a pressure as corresponds to its greatly reduced temperature.

The advantages possessed by a condensing over a non-condensing engine will now be obvious. When the piston is being forced from C to D by steam entering through C, the force on the back of the piston resisting its motion in that direction, instead of being equal to the pressure of the atmosphere, is only the pressure of the steam in the condenser, or about 2 lb. per square inch. The net effective force is therefore 60 - 2 or 58 lb. instead of 60 - 15 or 45 lb.

We have supposed that our cylinder when full of steam contained just one pound-weight at 60 lb. pressure. Let us now find out how much useful work this pound of steam has done for us, and we will then show how the same weight may be made to do a great deal more, by utilising more of its great store of heat. Let us suppose that the area of the cylinder is 2 square feet, while its length (the stroke of the piston) is $3\frac{1}{2}$ feet. It will thus have a capacity of 7 cubic feet, as before assumed. In the first case described we should have a pressure of 45 lb. per square inch exerted on an area of 288 square inches through a distance of $3\frac{1}{2}$ feet. This is equal to 45,360 foot-pounds of work. In the second case we have a pressure of 58 lb. per square inch on the same area and through the same distance. This is equal to 58,464 foot-pounds of work, or about $\frac{1}{4}$ of the total heat supplied by the fuel. (For simplicity's sake we have here assumed that the water in the boiler has to be raised from 32° to 212°, and evaporated at that temperature. If the water were supplied at 212°, then the work done would be about $\frac{1}{4}$ instead of $\frac{1}{8}$ of the total heat.) We may now proceed to examine the way in which the same weight of steam, generated by the consumption of an identical weight of fuel, may be made to perform many times more work by 'working expansively.'

One of the properties possessed by steam, in common with all other gases, is a tendency to expand indefinitely; its pressure varies nearly inversely as its volume. For simplicity's sake we shall here assume that steam is a perfect gas, and follows Boyle's law, the pressure varying *exactly* inversely as the volume. If then we have a cylinder of the same area as before, but of twice the length, but only intend to admit 1 lb. of steam into it at a time, it will be necessary, when the piston has travelled $3\frac{1}{2}$ feet of its stroke, to shut the entrance valve, so as to prevent more steam entering; this is called 'cutting off' the steam. The piston, however, still continues its motion in the same direction as before, propelled by the internal repulsive energy among the particles of steam. But as it is pressed forward the space occupied by the steam is always increasing, and its pressure always decreasing in proportion, until at length, when the piston has reached the end of its stroke, the steam occupies exactly double its original volume—viz. 14 cubic feet, and is reduced in pressure to half its original pressure—viz. to 30 lb. per square inch. We have thus during the first half of the stroke a constant pressure on the piston of 60 lb. per square inch, and during the second half a pressure gradually decreasing from 60 to 30 lb. The mean pressure during this second half of the stroke will be found on calculation to be almost exactly 40 lb. Let us now, in the same way as before, see what work we have been able to get out

of our pound of steam by expanding it in this way. In the first half of the stroke we have 58,464 foot-pounds of work exactly as before, and then we have in addition a mean pressure of $40 - 2$, or 38 lb. per square inch, exerted over 288 square inches for a distance of $3\frac{1}{2}$ feet. This equals 38,304 foot-pounds, making a total of 96,768 foot-pounds of work obtained from the steam which only gave us 58,464 before. The economy of working expansively, however, goes much further than this. If the cylinder had been four times its original length, and the steam had been cut off at the same point as before (which would then be quarter instead of half stroke), we should have obtained from the 1 lb. of steam about 144,000 foot-pounds of work. If we had gone still further and expanded the pound of steam into eight times its original volume, we should have obtained about 180,000 foot-pounds of work, which is more than three times as much as at first. (In actual working, owing to various causes—such as imperfect action of the valves, radiation from the cylinder, bad vacuum, &c.—the work obtained from the steam is not more than $\frac{65}{75}$ of that given in this paragraph.) All modern engines are worked more or less on this principle of expansion, and the general tendency seems to be every year to adopt higher initial pressures and (within certain limits) larger ratios of expansion.

Fig. 3 represents Watt's 'double-acting' condensing engine. By 'double-acting engine' we mean an engine such as was sketched in fig. 2, in which the steam acts on both sides of the piston instead of only on one, as in Newcomen's engine. Watt's engine, though not of the form now generally used, contains all the parts now considered essential. The steam from the boiler passes direct to the valve-chest, *v*, which is simply a long box attached to the cylinder, *a*. In this chest are placed valves, which are so regulated as to open communication between the boiler, cylinder, and condenser, in such a way that when the top of the cylinder is open to the boiler the bottom communicates with the condenser, and vice versa. When the steam has done its work it passes out through

the bent pipe into the condenser, *f*, where it is met by a jet of water (not shown in the engraving), and condensed, as before explained; *g* is a pump called the air-pump, which continually draws away the contents of the condenser, and discharges them into a cistern, *h*, called the hot well. A small force-pump, *j*, draws part of the water from this cistern, and sends it back again to the boiler, there to be reconverted into steam, while the rest of the water is allowed to run to waste. A suction-pump, *k*, supplies water to the large tank round the condenser, and also for the condensing jet. Inside the cylinder are the piston and the rod (called the piston-rod) connecting it with the beam, *bb*. In Newcomen's engine the rod had only to pull the beam down, and not to push it up; it could, therefore, be connected to it by a chain, as shown in fig. 1. In the double-acting engine the piston-rod is required both to pull and to push the beam, so that the chain is no longer admissible. It is obvious that as the head of the rod must move in a straight line, while every point in the beam describes an arc of a circle, the two cannot be rigidly connected. Watt invented the arrangement of rods shown in fig. 3, by which the piston-rod head is always guided in a straight line, while the end of the beam is left free to pursue its own course. This is called a 'parallel motion.' The end of the beam farthest from the cylinder is connected by a rod, *cc*, called a connecting-rod, to the crank, *l*, which is firmly fixed on the shaft; and by this means the reciprocating motion of the beam is converted into the rotary motion of the 'crank-shaft,' *r*. The governor, *m*, and the flywheel, *ee*, will be explained further on.

The cylinder and its piston are both made of cast-iron. The former is very accurately bored in a special machine, and ought always to be covered outside with non-conducting material to prevent radiation of heat. It is frequently enclosed in another cylinder, and the annular space or 'jacket' between them filled with steam from the boiler, principally with the object of preventing liquefaction in the cylinder, which is fatal to economical working. The openings for the entrance and discharge of the steam (shown at *C* and *D* in fig. 2) are both called *ports*.

The valve or valves which regulate the admission of

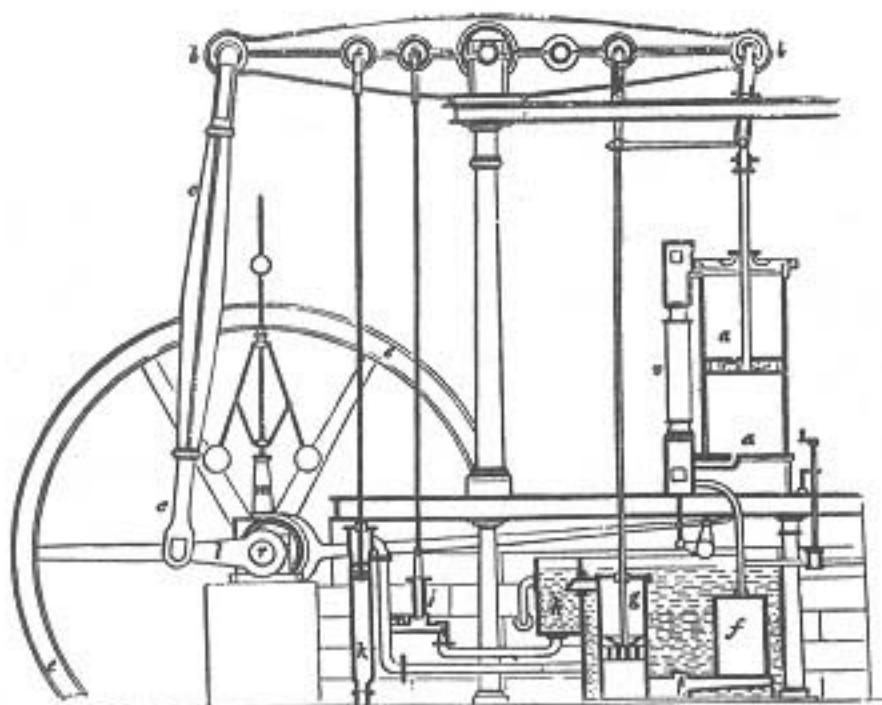


Fig. 3.

steam to the cylinder vary very much in construction and design. In ordinary engines one valve, called a *slide-valve*, does the whole work for each cylinder in a way which we shall explain by the aid of fig. 4. This figure shows the valve in two positions—viz. those corresponding to the times when the piston is at the middle of its stroke, going in the two different directions; *c* and *d* are the ports, the ends of which are denoted by the same letters in fig. 2; *b* is the 'exhaust port,' or opening through which the steam passes to the condenser; and *a* is the slide-valve working inside the steam-chest (the latter not shown). The sketch to the left shows the position of the valve when the piston is moving upwards. The steam enters the cylinder through *d*, as shown by the arrows, while the steam in the other end is free to rush

out by *c* under the valve, and through *b* into the condenser. By the time the piston has reached the same position, going in the opposite direction, the valve is in the position shown in the right-hand sketch, and the motion of the steam is exactly reversed. The valve in fig. 4 opens one port at the same moment as it closes the other. This corresponds to entirely non-expansion working. In order to 'cut off' the steam before the end of the stroke the breadth of the ends of the valve must be increased. This is called giving 'lap' to the valve. When it is desired to 'cut off' the steam earlier than half-stroke, a separate valve, called an *expansion valve* (of which there are innumerable varieties), is generally used. The rod to which the piston is attached is called the *piston-rod*, and the rod which actually drives the crank the *connecting-rod*. In Watt's engine and similar machines these are connected to opposite ends of a *beam*, but in the common type of engine shown in fig. 6 (below) the two rods are directly attached. The *flywheel* is a large wheel fixed on the crank-shaft, and having a very heavy rim. As it revolves this contains, stored up in itself, a great quantity of energy, and so equalises the motion of the shaft, and by restoring some of the energy enables the engine to pass



Fig. 4.

the 'dead-points,' or points at which the connecting-rod and crank are in a line. The *condenser* is simply a cast-iron box of any convenient shape. The water for condensing the steam is introduced into it in a jet in such a way that its particles mix with the steam at once on entering, and condense it almost instantaneously.

The *governor*, shown in fig. 5, is an ingenious application by Watt of mechanism long used in water-mills. Its object is to make the engine to

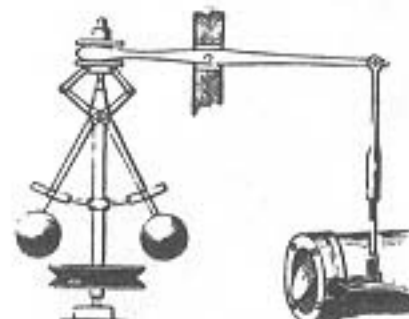


Fig. 5.

a great extent regulate its own speed, so that it shall neither be pulled up altogether by a sudden increase of load, nor 'race' when any part of its load is suddenly removed. It consists essentially of a spindle or upright rod, with a pulley by which it is caused to revolve fixed on it. Two levers are pivoted on a pin near the top of the spindle, and at the lower end of each is fixed a heavy cast-iron ball. When the engine is running at its proper speed the balls revolve with the spindle in the position shown; but if that speed be increased the centrifugal force causes them to fly outward, and consequently upward; and conversely, if it be decreased they fall downward towards the centre. At the upper end of the spindle is a system of levers, by which it will be seen that the raising of the balls tends to close, and their lowering to open, the *throttle-valve* at the right of the engraving. The valve in the figure is simply a disc of metal placed in the steam-pipe near the cylinder, but a great many other types of valve—more expensive but more efficient—are now used for the same purpose. The further this valve is opened the greater the amount of steam admitted to the cylinder, and vice versa, and so the tendency of the engine to alter its speed arising from causes extraneous to itself is just balanced by the alteration made in the amount of steam admitted through the throttle-valve. In order that economy as well as regularity of working may be attained, it is in many cases necessary that the governor should be so arranged as to control the 'cut-off' instead of throttling the steam as in the figure.

The 'Cornish' engine, so called from the fact that it is principally used in the Cornish mines, resembles Watt's engine in general appearance. Like Newcomen's engine it is used exclusively for pumping and has no rotary motion, and it is virtually single-acting; but, unlike his, the steam-pressure and not that of the atmosphere actually does the work. Cornish engines are fairly economical of steam, but are very costly and extremely heavy and unwieldy.

Engines in which the piston-rod and connecting-rod are directly attached are called *direct-acting engines*, of which the horizontal engine shown in fig. 6 is the most common type. For all ordinary purposes direct-acting engines are rapidly superseding every other form. They possess the merit of having great simplicity and few working parts, and of all these parts being easily accessible to the engine-driver; and at the same time any required degree of economical working can be obtained in them as well as in any other form. They were at first only used as non-condensing (or so-called 'high-pressure') engines, but are now as frequently made with a condenser attached.

Two other forms of direct-acting engines have been much used in their day, but are now being rapidly abandoned except under special circumstances; these are called respectively the 'oscillating' and the 'trunk' engine. In the former (which has rarely been used except for marine engines) the crank-shaft is above the cylinder, the piston-rod head is attached to the crank-pin, and the connecting-rod is dispensed with by allowing the cylinder to oscillate on large hollow centres called *trunnions*, and so to adapt itself to the various positions of the crank-pin. In the 'trunk' engine the piston-rod becomes a hollow cylinder or *trunk*, large enough to allow the connecting-rod to vibrate inside it. The latter is then attached at one end to the crank-pin as usual, and at the other to a pin fixed in the piston.

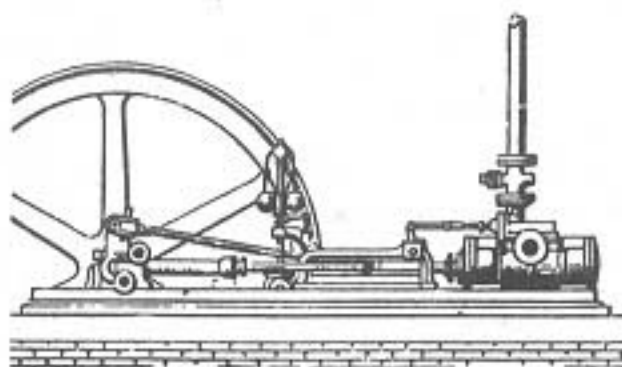


Fig. 6.

Direct-acting engines are now made to run at extremely high speeds, for driving dynamos, &c. direct. For this purpose they are made single-acting only, so that the steam-pressure tends always to keep the working surfaces pressed together, and there is none of the shock and noise found in ordinary engines where the direction of pressure is reversed at each stroke. The first successful machine of this type was Mr Brotherhood's 'three-cylinder' engine, of which an immense number are in use. Of late years Mr Willans, in his 'central valve' engine, has added an exceptional degree of economy in steam to the other advantages of the single-acting type. Willans' engines are now very commonly used in the more important electric lighting stations in Britain for the direct driving of dynamos, and have given most satisfactory results. An immense amount of ingenuity has been expended in devising engines in which the rotary motion of the shaft is obtained *directly* from the piston without the intervention of reciprocating parts. These machines are called *rotary engines*; they have never come into general use, and most of them have been defective in construction as well as founded on a dynamical misconception.

In *locomotive engines* it is necessary that the whole machinery should be compressed into the smallest possible bulk, and this necessity is the cause of their principal peculiarities. The engine itself is much the same as an ordinary horizontal engine, and has two cylinders placed side by side near the front of the locomotive. These cylinders are sometimes placed inside the main framing, which runs the whole length of the engine, and sometimes outside it, each plan having certain advantages. Fig. 7 is an outline section of an 'inside cylinder' goods-locomotive belonging to the Midland Railway Company. At the back of the locomotive is the firebox, *a*, the bottom of which is formed by the grate, *b*. Fuel is introduced by the door, *c*. The firebox is enclosed in a casing, *d*, and the space between is filled with water. This space communicates freely with the barrel, *e*, of the boiler, a long wrought-iron or steel cylinder. From the back of the firebox numerous

small tubes traverse the boiler (through the water) to the smoke-box, *f*, and conduct the products of combustion to the chimney, *g*. The steam-pipe, *h*, is led away from near the top of the dome, *k*, and fitted with a regulator valve, *l*. At *m* are a pair of spring safety-valves. Both cylinders discharge their steam through the vertical blast-pipe, *p*, and by this means a sufficient draught is caused, notwithstanding the small height of the chimney. The cylinders, *r*, are placed in the bottom of the smoke-box, and partly enclosed in it.

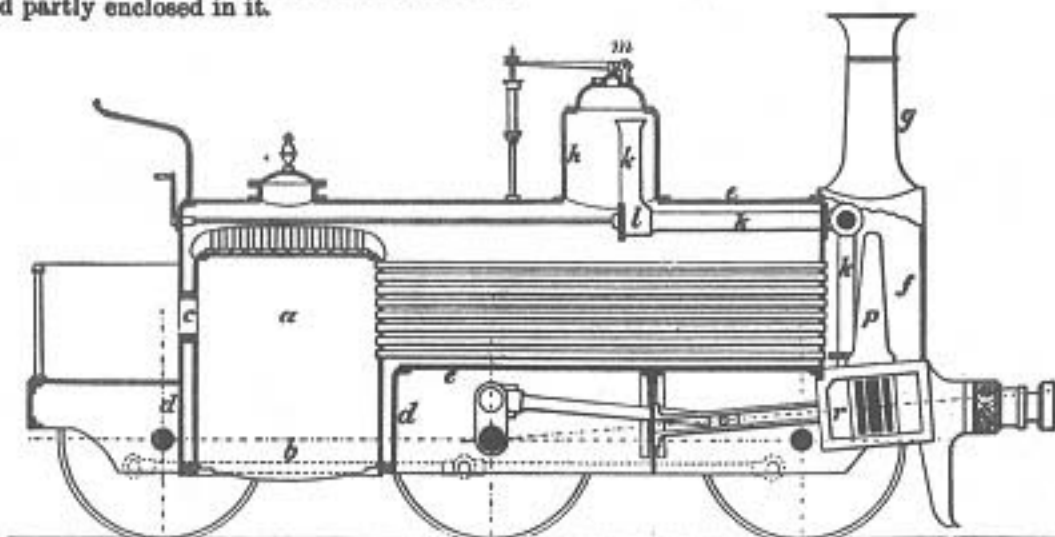


Fig. 7.

In all *marine engines*, except the very smallest, two cylinders are used, working cranks at right angles to each other, so as to equalise the motion as far as possible, it being almost impossible to use a flywheel of sufficient weight for that purpose on board ship. The form originally known as the 'steam-hammer' engine (from the resemblance of early models to Nasmyth's steam-hammer), or some modification of it, is now almost universally adopted. They are direct acting, but the cylinders are inverted, and placed right above the propeller shaft. Two of the greatest improvements in the modern steam-engine—the *surface-condenser* and the *compound engine*—have been brought to perfection chiefly in connection with marine engines here. In the surface-condenser the steam is condensed by contact with the exterior surface of a great number of small tubes, through the interior of which a current of cold sea-water is kept constantly flowing. By this means the condensing water and the condensed steam are kept separate, the former being returned to the sea, and the latter only sent into the hot well. The boiler, therefore, is continually fed with distilled water, and the wasteful process of 'blowing off,' to get rid of the unworkable matter which would otherwise be deposited in the boiler, is rendered unnecessary.

In 'compound' engines the two cylinders are of unequal size—the larger, called the low-pressure cylinder, having from three to four times the capacity of the smaller or high-pressure cylinder. The steam from the boiler is admitted into the latter in the usual way, and cut off generally at from $\frac{1}{2}$ to $\frac{3}{4}$ of the stroke; and after doing its work there, it is conducted to the large cylinder, where its reduced pressure, by acting on an increased area, does as much work as in the other cylinder, and thence to the condenser. This system of engine has several notable advantages—among which are that the driving pressures are more uniform than in ordinary engines; that leakage past the piston becomes of less importance; that for any given large measure of expansion the mechanism of the engine is much more simple than for the same degree of expansion carried out independently in two cylinders; and that the losses due to condensation of steam in the cylinders (which are now known to be among the most serious of all causes of waste) are much reduced.

In modern marine engines, and to some extent also in mill engines, the compound principle is now carried further, and 'triple expansion' engines (which are simply compound engines with three cylinders used consecutively instead of two) are very widely employed, with very economical results. In these engines steam is not uncommonly used at a pressure as great as 150 lb. per square inch, or six times as much as was usual about 1860. Quadruple engines are also used.

The Work done by Steam-engines is estimated

in two ways—as *horse-power* and as *duty*, and the first expression includes two things—nominal and indicated horse-power. Thirty-three thousand foot-pounds of work done per minute is called one horse-power, this being considered by Watt as the maximum rate at which a strong horse can work. The *nominal* horse-power of an engine has long ceased to be any expression of the actual power it exerts; it is only used as a kind of commercial standard (a very deficient one) for the

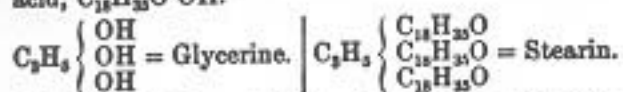
sale and purchase of engines, and is generally made to depend entirely on the diameter of the cylinder. The *indicated* horse-power is the most useful measure we have of the work done by an engine. It expresses, however, not the work itself, but the rate at which that work is being done in the cylinder. It has to be remembered also that it does not show at all what proportion of that work has to be expended in overcoming the friction of the engine itself. It is ascertained by the use of a little machine called an 'indicator,' devised by Watt, and since his time greatly improved, especially by Richards and by the Crosby Company. By taking the mean pressure per square inch on the piston throughout the stroke (measured from the indicator diagram), and multiplying it by the area of the piston and by the number of feet passed through by it in a minute, we can find the number of foot-pounds of work done by the engine per minute; and this, divided by 33,000, gives the indicated horse-power.

'Duty' is an expression used only for pumping-engines, and differs from horse-power in being entirely independent of time—i.e. it is a measure of work done, and not of the rate at which it is done. It is the number of foot-pounds of nett work resulting from the consumption of a given quantity of coal, usually either a bushel of 94 lb. or a cwt. At the beginning of the 19th century the maximum duty that had been attained by any Cornish engine was 20 millions of foot-pounds per cwt. of coal, but six times that duty has since been occasionally obtained. In these engines it is the actual nett work done which is taken into account; the duty would be 20 or 25 per cent. greater if the total load on the steam-piston had been considered instead.

For engines whose power can only be measured by the indicator the standard of economy is the number of pounds of steam used per hour per indicated horse-power. A first-class non-condensing engine, working with steam of about 100 lb. pressure, uses about 22 lb. of steam per i.h.p. per hour, which is reduced to 17 or 18 lb. by the employment of condensation. Occasionally better results than these are obtained, but in ordinary good work the figures are at least 25 per cent. greater, and they are often more than double as great. In any case economy is only to be obtained if the engines are worked at or near their full power, and with the full steam-pressure for which they are intended. It is very common to speak of the amount of coal burned per i.h.p. per hour, and this is a very important quantity. It is, however, a measure of the combined economy of a boiler and engine, and not of the economy of an engine alone. A pound of Welsh coal can be made to evaporate 10 to 11 lb. of water under special conditions. In ordinary circumstances and over long periods the evaporation is more like 7½ to 9 lb. of water per lb. coal. Inferior fuels, or

even good fuel badly burned, give, of course, very much lower results.

Stearin, $C_{18}H_{37}(O \cdot C_{17}H_{33}O)_2$, is one of the fats occurring in animals and plants. Like the other fats it may be regarded as an ether of the triatomic alcohol glycerine, all three hydroxyl molecules being replaced by radicles of the fatty acid—stearic acid, $C_{17}H_{33}O \cdot OH$.



It is the chief constituent of the more solid fats, such as mutton suet, and is characterised by its high melting-point—from 53° to 66° C.—by its slight solubility in alcohol as compared with palmitin and olein, and by its crystallising from its alcoholic solution in the form of brilliant quadrangular plates. Like the other fats it may be readily split into glycerine and a fatty acid, and if an alkali be present the acid combines with this to form a soap. Stearoptene is the crystalline solid substance which separates from volatile Oils (q.v.) on long standing or at low temperatures. For Physiology of Fats, see FAT.

Steel. The discovery of a material which is capable of cutting and otherwise shaping nearly every other substance known to man, and which can be so modified in hardness as to be able also to easily cut and otherwise shape itself, was of sufficient importance to make a distinct epoch in the progress of the human race. Such a material is steel, which may be made nearly as hard as the diamond, or so soft that it can be cut, bent, or hammered into any shape, rolled into sheets, or drawn into wire even of hair-like thinness. It is composed of iron and carbon, but is not a true chemical compound of these substances. True chemical compounds have fixed and definite proportions of the elements composing them, but steel varies in all proportions from $\frac{1}{2}$ per cent. of carbon to $2\frac{1}{2}$ per cent. The more carbon the greater becomes the hardness of the steel, until a limit is reached owing to the brittleness which accompanies the hardness. The fusibility of steel increases with the amount of carbon. Ordinary steel contains a little silicon, manganese, sulphur, phosphorus, &c., but these are merely impurities. The removal of these, or their reduction to the smallest possible quantity, is very desirable, as upon such removal the quality of steel mainly depends. These impurities are derived partly from the iron ores and partly from the fuel used in smelting them. When a pure ore, such as the magnetic oxide of iron, and a nearly pure carbon, such as wood-charcoal, are used, the manufacture of steel of fine quality is very simple and easy. With such materials steel is made quite as easily as iron, the carbon of the fuel readily combining with the iron as it becomes reduced from the ore. The ancient iron-makers obtained their steel in this way, and the ironmasters of the East, who still work in the primitive manner with small furnaces and much labour, do the same, but they are not able to accurately regulate the quantity of carbon in the steel and its consequent hardness.

Owing to the scarcity of these pure iron ores and the high cost of charcoal, they are but little used by the modern steel-maker, who adopts a very roundabout process, the true reasons for which have been much misunderstood. He first makes an impure steel (pig-iron or cast-iron) containing 3 or 4 per cent. of carbon, then he reduces this quantity to about $\frac{1}{2}$ per cent. or less in making malleable or wrought iron by puddling (see IRON), and afterwards by another expensive process restores about half as much carbon as he has taken away. Steel has been defined by high scientific authority as 'iron carbonised in degrees intermediate between malleable and cast iron,' a description that has led to a multitude of futile and costly attempts to produce steel by mixing cast and wrought iron together, and other similar devices for simply diminishing the proportion of carbon. Such devices would be successful if cast-iron were a compound or mixture of iron and carbon only; but ordinary cast-iron contains silicon, sulphur, and phosphorus in quantities that are ruinous to steel.

The modern maker of the best steel therefore uses the best puddled iron, preferably Swedish charcoal iron. He has it rolled into bars, usually

3 inches wide and $\frac{3}{4}$ inch thick, and 10 to 15 feet long, and submits these to a process which has received the name of cementing. The cementing-furnace is a circular brick structure terminating upwards in a wide truncated conical chimney of somewhat dome-like appearance, a familiar feature in the gloomy landscape of Sheffield. Fig. 1

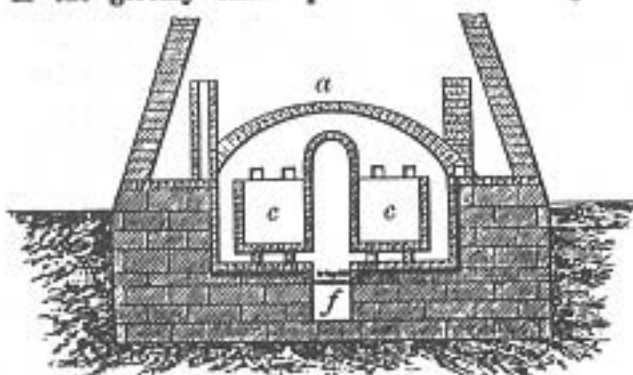


Fig. 1.

shows it in section with the upper part of the chimney cut off: *f* is the ashpit with the bars of the fireplace seen endwise above; *c, c* are two 'chests,' or converting pots, shown in section. These are made of firebrick or firestone, and supported over the fire, with flues so arranged that the flame and smoke shall pass up the arched space between them, and below and around their outer sides, so as to heat them all round as equally as possible. The smoke and lurid smoky flame after traversing these flues rise into the arch, *a*, which is thus heated and consequently radiates downwards to the upper side of the chests.

The chests, 15 to 18 feet long and $2\frac{1}{2}$ to 3 feet deep and same width, are charged by first spreading over the bottom a layer of coarsely-ground charcoal (from hard wood preferred) about 2 inches deep. Upon this is placed a layer of bars with a space of $\frac{1}{2}$ to $\frac{3}{4}$ inch between each. Over these bars and into the spaces between them is sifted another layer of charcoal to about an inch deep above the bars; then another layer of bars, and another of charcoal, and so on, up to within 6 inches from the top. Then old 'cement powder'—i.e. charcoal already used, and grinders' waste—is moistened and plastered over this, and the whole covered with clay or moistened sand to exclude the air. All is now closed in excepting the ends of some extra long 'tasting bars,' which are allowed to protrude from the 'tasting' or testing holes. A glowing red heat is maintained for eight or ten days, when a tasting-bar is withdrawn to ascertain whether the carbon has penetrated sufficiently. When this is the case the furnace is allowed to cool slowly during another week or thereabouts. When the bars are withdrawn they are found to be coated with a sort of dark skin which is raised in blisters over a large part of their surface. It is by the appearance of these and by fracture that the quantity of carbon taken in and the depth of its penetration is ascertained. This transference or penetration of solid carbon into solid iron is a mystery, the theory of which has been much discussed, too much so for exposition here. An important practical fact is, however, connected with it—viz. that the distribution of the carbon is very unequal. Its quantity is greatest on the surface, and gradually decreases towards the interior. Therefore the steel in this state, 'blister steel,' is of little value on account of its irregularity of composition and consequent irregularity of hardness, &c. To remedy this the outskides and insides of the bars have to be stirred up and mixed together so as to give uniformity of composition to the whole.

The most obvious mode of doing this is to melt the whole and stir the fluid. This is done in making the very best quality of steel—'cast-steel' or 'pot-steel,' as it is called in Sheffield. The bars are cut into small pieces, melted in crucibles, and then poured from these into ingot moulds. Oxide of manganese and ferrocyanide of potassium are added in small quantities to the melted metal in the crucibles. The theory of the action of these additions has been much debated, and its discussion would occupy too much space for this article. The consumption of fuel, the labour, and the destruction of crucibles renders this melting an expensive process and the result correspondingly dear. A cheaper mode of mixing is adopted in the production of what is called 'shear-steel.' The blistered

bars are cut or 'sheared' into short lengths; these are bound together into bundles or 'faggots,' raised to a welding heat—i.e. heated until they become sufficiently soft to be plastic, then placed under a

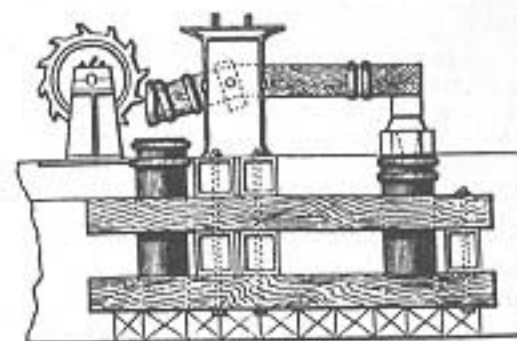


Fig. 2.

'tilt hammer,' shown in fig. 2. The tail of this hammer is struck by the cams of the revolving wheel, whereby the head is lifted, and falls again before the next cam comes into action. In this manner the faggot receives 300 to 400 heavy blows per minute, the rapidity of percussion fully maintaining the heat of the faggot, while its constituent pieces are welded into one coherent mass. This is then rolled out into a long bar which is resheared into small pieces to form another faggot to be similarly treated. The reshearing, &c., may be repeated as often as demanded, and thus we have 'single shear,' 'double shear,' &c. None of these are so homogeneous as crucible steel, and they are therefore inferior in this respect.

A very important development of the manufacture of steel has followed the introduction of the 'Bessemer process,' by means of which a low carbon or mild cast-steel of inferior quality can be produced at about one-tenth of the cost of crucible steel. It is used for rails, for the tires of the wheels of railway carriages, for ship-plates, boiler-plates, for shafting, and a multitude of constructional and other purposes to which only wrought-iron was formerly applied, besides many for which no metal at all was used.

This process was originally based on the theory—then generally accepted—that steel is 'iron carbonised in degrees intermediate between malleable and cast iron;' and, as carbon is readily oxidised at a high temperature and thus converted into gaseous compounds, nothing further was supposed to be necessary for the conversion of cast-iron into steel than to blow through the melted cast or pig iron a sufficient quantity of air to burn out the redundant carbon and leave behind the proportion required for the production of steel. A large number of patents were secured, including various devices for doing this, and all failed. A sort of steel was produced, but it was unworkable. When hammered, either hot or cold, it either crumbled to pieces or split at its edges when flattened down. The sources of failure were twofold. The first was that ordinary pig or cast iron contains other impurities than carbon, notably silicon, sulphur, and phosphorus. The carbon was readily removed by oxidation, and gradually, as demanded by the theory; the silicon was also oxidised even more readily than the carbon, but the sulphur and phosphorus remained obstinately, even after nearly all the carbon was oxidised and the iron itself began to burn. The other difficulty was that of regulating the quantity of carbon, by stopping when the required quantity was removed by oxidation. This difficulty was overcome by Mr Robert Mushet, who used a compound of iron and much carbon, known composition (spiegeleisen), and added this in the quantity necessary to give to the whole the proportion of carbon required. Thus, if the spiegeleisen contained 5 per cent. of carbon, and 1 per cent. was required in the steel to be produced, spiegeleisen was added to the decarburated iron in the proportion of 1 to 4.

After considerable struggles the first difficulty was partially overcome by using only special kinds of pig-iron, those made from hematite ores which contain very little phosphorus. Mr Mushet's 'triple compound,' the spiegeleisen, also assisted here, as it contains a considerable amount of manganese, which exerts a purifying influence on steel. The rationale of this purification has been much debated; the experiments of the writer indicate that manganese acts by removing the last vestiges of silicon and particles of oxide of iron in the Bessemer converter. Its practical usefulness, how-

ever, is unquestionable. But the Bessemer steel even thus produced is far inferior to the crucible steel or shear-steel. There is still sufficient phosphorus in it to render it unfit for making tools with acute edges, or for files, saws, &c. If highly carburetted its hardness is accompanied with brittleness that causes cutting-tools to notch, and toothed-tools, like saws and files, to strip. Phosphorus gives hardness of a glassy character.

The Bessemer 'Converter' is shown diagrammatically in section in fig. 3. It is a strong iron vessel lined with refractory material. The bottom, which is removable for renewal, is fitted with fire-clay cylinders, *cd, cd, cd, cd*, and each cylinder is perforated with several holes $\frac{1}{2}$ to $\frac{3}{4}$ inch in diameter. It is thus riddled with sixty to a hundred holes, according to its size. These perforations

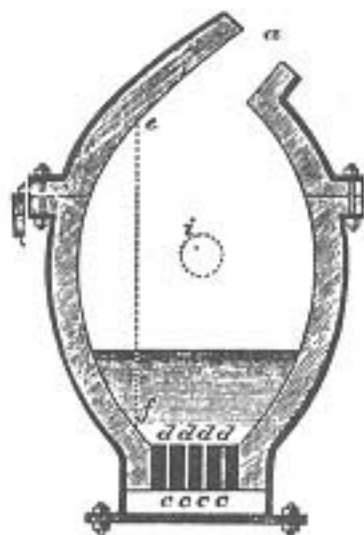


Fig. 3.

communicate by means of an air-chamber, *c, c, c, c*, with a powerful blowing-machine. The whole converter is mounted on an axis, *b*, and may be thereby turned as required.

The lining is first made red-hot by burning coal within. When thus prepared ready for charging, the converter is turned on the axis, *b*, so that the line, *ef*, shall be horizontal. Molten pig-iron is then poured in at the mouth, *a*, and thus it forms a pool lying in the belly of the

converter below the line, *ef*. The blast is now turned on, and the converter turned over to the position shown in the diagram, the melted metal standing over the hundred open holes. It cannot, however, run down these, as the blast of air rushes upwards with much greater force than that of the downward gravitation of the metal. The streams of air tear through the molten metal, and a huge flame roars furiously from the mouth of the converter. With this flame brilliant cascades of coruscating sparks are belched forth at irregular intervals, and the dazzling spray as it dashes against the wall of the flame-shaft rebounds with redoubled splendour. The blast still roars on monotonously, and the flame steadily increases in size and brilliancy, attaining its maximum at about the end of ten minutes. It continues thus for five or ten minutes longer, then the flame contracts. This indicates that the carbon is becoming exhausted, and that the iron, no longer protected by it, is beginning to burn. The converter is now turned to the position in which it was charged, and then the melted spiegeleisen is poured into it. A violent ebullition occurs immediately this mixes with the metal that has been blown, and a great waving blue flame of burning carbonic oxide silently pours out of the mouth of the converter.

Why this violent agitation, and whence comes this great outpouring of gas? The writer studied these questions experimentally when the Bessemer process was young, and found that the carbon is not all burned out, as was then supposed. There remained from $\frac{1}{2}$ per cent. to $\frac{1}{10}$ per cent. according to the prolongation of the blowing, and besides this there was a considerable quantity of black particles of oxide of iron in the blown metal before the spiegeleisen was added, but after this addition they disappeared. These facts answer the questions. The carbon of the spiegeleisen reduces the black oxide by combining with its oxygen, and this combination with oxygen produces the carbonic oxide. The manganese assists, for much of it disappears from the metallic product, and is found in the liquid cinder (or 'slag') combined with oxygen and silica. The blown metal, before the addition of the spiegeleisen, is 'rotten'; it breaks under the hammer whether hot or cold. If overblown it crumbles like sandstone.

One of the most remarkable phenomena of the Bessemer process is the intense heat to which the metal is subjected. It far exceeds that obtained in any other melting furnace. At first glance this

may appear strange, as nothing but cold air is applied to the melted metal. But this metal is pig-iron containing silicon and carbon. Both of these are effective fuels when heated and supplied with oxygen. The manganese adds a little. In an ordinary charge of six tons of average material these fuel substances amount to about 8 cwt. They are all burned in the course of about twenty minutes, not outside a melting-pot, but within or amidst the melted metal itself; and thus the heat of this extraordinary amount of combustion in so small a space is rendered exceptionally effective. After the spiegeleisen is all added and well admixed by the agitation it produces, the liquid steel is poured into ingot moulds of suitable sizes according to its purpose, and these are wrought by hammering, rolling, &c. as required.

Owing to the phosphorus contained in ordinary Bessemer steel, it will rarely bear as much as 1 per cent. of carbon without becoming worthless brittle, and therefore only mild or low carbon steel is made from it for purposes already stated. Messrs Thomas and Gilchrist have succeeded in removing the most of this residual phosphorus by lining the converter with a basic material, a refractory substance in which lime and magnesia preponderate. These bases eagerly combine with phosphoric acid at high temperatures, and by their predisposing affinities assist the phosphorus in combining with the oxygen of the blast to become the phosphoric acid which they demand. The phosphates of lime and magnesia thus obtained are valuable manures. The practical value of the basic process depends mainly on its rendering impure pig-iron available.

The 'Siemens-Martin process' is now competing very effectively with the Bessemer process. It consists essentially in first obtaining a bath of melted pig-iron of high quality, and then adding to this pieces of wrought-iron scrap or Bessemer scrap, such as crop ends of rails, shearings of plates, &c. These, though practically infusible in large quantities by themselves, become dissolved or fused in such a bath if added gradually. To the bath of molten metal thus obtained spiegeleisen or ferro-manganese is added to supply the required carbon and to otherwise act as already described in the Bessemer converter. The result is tested by small ladle samples, and when it is of the desired quality a portion is run off, leaving sufficient bath for the continuation of the process.

It is evident that here a high degree of purity is attainable by selection of the scrap, which may be of high quality wrought-iron from which the impurities have been removed by puddling. Very fine samples of 'homogeneous metal' have thus been obtained, resembling wrought-iron in softness and toughness, with some degree of the high tenacity of cast-steel. Where qualities like those of ordinary Bessemer metal are required, this process supplies an economical method of melting up and utilising such materials as old Bessemer rails, &c.

Tempering.—The special property upon which the great value of steel depends is that of being capable of acquiring various degrees of hardness. These are obtained by what is commonly called 'tempering,' which really includes two processes—(1) hardening and (2) tempering properly so called. If a piece of steel containing $\frac{1}{2}$ per cent. of carbon and upwards is made red-hot and then suddenly plunged into cold water, or otherwise rapidly cooled, it becomes hardened in proportion to the quantity of carbon it contains. In this condition it is of very little use, as it becomes brittle in proportion to its hardness; but this brittleness and extreme hardness may be tempered by reheating in various degrees according to the degree of hardness required. This is the tempering process properly so called.

The workman has discovered a simple and elegant means of determining the temperature attained in this reheating. A film of oxide is formed, and as this thickens its colour changes as shown in the table below. Another method of fixing the temperature is by immersing the tool in a bath of fusible metal or alloy just at its melting-point, which melting-point varies with the composition of the alloy. A third is to smear the surface with tallow and watch the result. The following table shows these results, the temperature at which they occur, and the alloys that may be used.

Colour.	Temperature.	Alloy.	Effect on Tallow.
1. Pale straw....	430° F.	7 lead 4 tin	Vaporises.
2. Straw	450°	8 " 4 "	Smokes.
3. Straw yellow....	480°	8½ " 4 "	More smoke.
4. Nut brown....	500°	14 " 4 "	Dense smoke.
5. Purple	530°	19 " 4 "	Black smoke.

6. Bright blue...580°	48	"	4	"	Flashes if light is applied.
7. Deep blue590°	50	"	2	"	Continuous burning.
8. Blackish blue..640°	{ All lead or boiling lin-seed-oil }				All burns away.

Long exposure to the temperatures named has an effect similar to that of a higher temperature. The usual practice is to plunge the article into cold water immediately the required temperature is reached, and the above table is based on this practice. Varying temperatures, or degrees of softening or 'letting down,' are demanded according to the purposes for which the tool is used. No. 1—pale straw—is the temper for tools used in cutting iron and steel, for lancets and some other surgical instruments. Nos. 2 and 3 for tools used in cutting brass. No. 3 for penknives and tools of this class. No. 4 for scissors, stone-masons' chisels, and the strongest tools used for cutting hard wood. No. 5 for table-knives, clasp-knives, and ordinary edged tools for cutting soft wood. No. 6 for swords, bayonets, axes, &c. No. 7 for watch-springs, needles, fine saws, and other tools where elasticity is demanded. This is called 'spring-temper.' No. 8 for common wood-saws, and other tools used for soft material. Steel is softened by heating to redness and cooling very slowly (see ANNEALING).

Straw, MANUFACTURES OF. Apart from the importance of the straw of various cereal plants as a feeding and bedding material in agriculture, such substances also possess no inconsiderable value for packing merchandise, for thatching, for making mattresses, and for door-mats. Straw is also a paper-making material of some importance, and split, flattened, and coloured it is employed for making a mosaic-like veneer on fancy boxes. But it is in the form of plaits that straw finds its most outstanding industrial application, these being used to an enormous extent for making hats and bonnets and for small baskets, &c. Wheat straw is the principal material used in the plait trade, the present great centres of which are Bedfordshire in England, Tuscany in Italy, and Canton in China. At first the plait was what is called *whole straw*; that is, the straw was cut into suitable lengths without knots, and merely pressed flat during the operation of plaiting; and so it continued until the reign of George I., when it was in great demand for ladies' hats, and some plait was made of split straw. Since that time split straw has been chiefly used. The instrument employed for splitting (fig. 1) consists of a number of little square steel blades radiating from a stem which terminates in the point *a*, and at the other end is bent and fixed into the handle *b*. The point *a*, being inserted into the hollow of

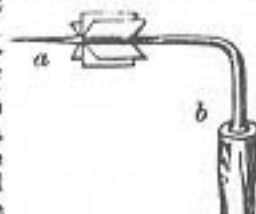


Fig. 1.

the straw, is pressed forward, and cuts it into as many strips as there are blades in the cutting-tool. The English straw used in plaiting is obtained principally from the varieties of wheat known as the White Chittim and the Red Lammas, which succeed best on the light rich soils of Bedfordshire and the neighbouring counties. Only bright, clear, and perfect pipes can be employed, and to obtain the straw in good condition great care has to be exercised. The crop is not mowed, but pulled up, and the ears are cut off by the hand for thrashing. The straws are then cut into lengths, cleared of their outer sheath, and assorted into sizes in a kind of sieve apparatus like fig. 2. The apertures

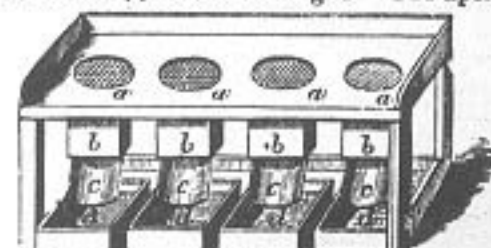


Fig. 2.

in each successive perforated top are increasingly wider, so that fine straws only pass through *a* by the shoot *b, c*, into the box *d* at the one end, and thicker pipes in each succeeding box. The plaits, made principally by women and children, vary greatly in pattern, quality, and cost.

(Volume 4 Entries Begin
with the Next Subject)